REMOTE POSSIBILITIES:

EXPLAINING INNOVATIONS IN AIRPOWER

Lawrence Spinetta

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Dr. Stephen Chiabotti, Chair

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Col Timothy Schultz, PhD

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Dr. Mary (Missy) Cummings

Certificate of Approval:
All Degree requirements fulfilled.
Degree Awarded 13 Jun 12 (Initial _____)

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Col Timothy Schultz, PhD
Commandant and Dean
School of Advanced Air and Space Studies

ABSTRACT

The rapid rise of unmanned aircraft over the last decade gives the misleading impression that the weapon suddenly blossomed out of nowhere. In reality, the technology dates back to the infancy of aviation itself. Indeed, unmanned aerial vehicles (UAVs) foundered as mere footnotes in aviation history for nearly a century before abruptly experiencing exponential growth, with no end in sight. That raises two questions: why now, and what can we anticipate for the future? This dissertation explores answers, investigating factors that underlie and influence weapon system innovation.

The investigation begins by surveying literature on military innovation. It discovers much of the literature addresses doctrinal innovation, a related but different line of research than the focus of this investigation. Nevertheless, the dissertation argues insights from doctrinal innovation are relevant and insightful, albeit insufficient.

To improve explanatory power, the dissertation proposes cross-disciplinary framework that merges insights from doctrinal innovation theory with ideas from diffusion of innovations (DOI) and business innovation research, adapted to fit a military context. The framework acknowledges that interservice competition and changes in a state's security situation, two factors identified in doctrinal innovation literature, can influence weapon system innovation. However, it maintains, per a central finding of diffusion of innovations (DOI) research, that the perceived attributes of innovations also weigh heavily in their adoption. Specifically, the study hypothesizes that four perceived attributes—relative advantage, compatibility, trialability, and observability—of which relative advantage is the most important, account for the majority of the variance in whether and how quickly new weapons are adopted. The investigation, however, notes a shortcoming in DOI research: it does not describe how the alluring attributes of new technologies overcome the inertial behavior of organizations. Fortunately, business innovation research informs this deficit.

Clayton Christensen, a Harvard Business School professor, identifies two patterns in commercial innovation that this study maintains are also exhibited in weapon system innovation. These two patterns inform how relative advantage can evolve to favor new classes of weapons over existing ones. First, the armed services, similar to commercial incumbents, perennially pursue "sustaining innovations." In a military context, that means developing ever-more-perfected versions of established weapon systems. This pattern of innovation leads to more capable weapons but adds layer upon layer of cost and complexity onto fewer platforms. At some point, perennial sustaining innovation paradoxically delivers new generations with diminishing relative advantages. Second, Christensen claims the adoption of "disruptive innovations" tend to follow a common pattern: from niche to mainstream. The equivalent in a military context is for new classes of weapons to first fulfill peripheral roles and then graduate to core missions, progressively displacing existing weapon systems commensurate with the rate at which their relative advantage evolves.

To test whether the new, cross-disciplinary framework offers greater explanatory power than the insights of doctrinal theory alone, the dissertation investigates three cases—the adoption of the Intercontinental Ballistic Missile (ICBM), the helicopter, and the UAV. It uses the results to speculate about the future of airpower, specifically the mix of manned and unmanned aircraft in the U.S. Air Force and U.S. Army inventories. While unmanned aircraft

appear poised to become more numerous and play a prominent role in virtually every mission area, the study predicts stiffening resistance from the fighter-pilot-dominated Air Force leadership as unmanned aircraft become more competitive with manned aircraft.

BIOGRAPHICAL SKETCH

Lt Col Lawrence Spinetta, USAF received a B.S. in Economics and Operations Research from the U.S. Air Force Academy in 1993. He also earned a Master of Public Policy from the John F. Kennedy School of Government, Harvard University in 1995 and a Master's degree in Airpower Art and Science from the School of Advanced Air & Space Studies in 2006. Lt Col Spinetta currently serves in the Joint Force Development (J-7) directorate of the Joint Staff, Pentagon. Previously, he commanded an MQ-1B Predator Squadron at Creech Air Force Base, completed multiple assignments as an F-15C pilot (65 combat sorties over the former Yugoslavia and Iraq), and served as an International Affairs Fellow at the Council on Foreign Relations.

ACKNOWLEDGEMENTS

I am deeply indebted to the three members of my dissertation committee: Dr. Steve Chiabotti, Col (Dr.) Tim Schultz, and Dr. Mary "Missy" Cummings (Massachusetts Institute of Technology). Dr. Chiabotti has been a phenomenal mentor ever since my first day of SAASS in 2005. Several years ago, I faced a professional fork in the road. Although I had flown the F-15 Eagle for more than a decade, the community was rapidly collapsing, the victim of creative destruction brought about by innovation. After being presented with the opportunity to switch tracks and command an MQ-1B Squadron, I sought Dr. Chiabotti's sage advice. Although unmanned aircraft historically have not been celebrated within the U.S. Air Force, he encouraged me, with an eye to the future, to take the "professional road less traveled." The experience has been immensely rewarding both personally and professionally. I am very grateful for his counsel over the years, his tireless efforts to improve my writing and thinking skills, and for the opportunity to pursue a PhD. Dr. Shultz, a role model whom I greatly respect, has also significant influenced my intellectual development. He showed great patience, commitment, and dedication reviewing my work, challenging me to sharpen my argument. As the commandant of SAASS, Dr. Shultz has shaped generations of strategic thinkers within the U.S. Air Force and done wonders strengthening the community of SAASS graduates. I first crossed paths with Dr. Cummings after we wrote contrasting editorials for *C4ISR Journal*. She most graciously welcomed the intellectual exchange and has done much to advance my thoughts on unmanned aircraft and the future of airpower. I owe her a ton of gratitude for taking the time to join my committee.

I would also like to thank Dr. Alex Roland and Dr. Thomas Ehrhard, both of whom helped shape and focus my dissertation. Dr. Roland provided valuable feedback on early drafts of several chapters and was particularly helpful getting me to improve my theoretical construct. Similarly, Dr. Ehrhard provided great support helping me to think through ideas, especially when it came to the relevance of innovation research in other fields of study. Indeed, Dr. Ehrhard introduced me to Dr. Everett Rogers's Diffusion of Innovations (DOI) theory, an indispensable part of this study. Additionally, Dr. Ehrhard's dissertation, which thoroughly chronicled the history of unmanned aerial vehicles (UAVs) from their early days until the year 2000, also proved helpful.

Finally, I owe an immeasurable debt to my parents whose love and support have made me who I am. I dedicate this dissertation to them.

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INTRODUCTION

"We're at a real time of transition here in terms of the future of aviation."[1]

— Admiral Mike Mullen, Chairman of the U.S. Joint Chiefs of Staff

At the end of World War II, General Henry "Hap" Arnold, Commanding General of the U.S. Army Air Forces, made a startling prediction: "We have just won a war with a lot of heroes flying around in planes. The next war may be fought by airplanes with no men in them at all. …. Take everything you've learned about aviation in war, throw it out of the window, and let's go to work on tomorrow's aviation. It will be different from anything the world has ever seen."[2] Arnold's vision of pilotless aircraft fighting America's wars was premature, but his prophecy appears to be coming true. The conflicts in Iraq and Afghanistan helped spark what may prove an unmanned revolution in airpower that is changing the way wars are fought. In recent years, no other weapon has more significantly transformed the way the United States wages war than unmanned aircraft.[3]

Over the last decade, unmanned aircraft progressed from experimental fringe to the most requested air assets in our nation's arsenal. As a result, they witnessed exponential growth, amassing flight hours at a frenzied and accelerating pace (see Figure 1). In 2001, the

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[1] "Mullen: Drones Future Stalwart of U.S. Force," *Defense News*, 14 May 2009, available at http://www.defensenews.com/story.php?i=4091274.

[2] Quoted in Jay M. Shafritz, *Words on War: Military Quotes from Ancient Times to the Present*, (New York, NY: Prentice Hall, 1990), 104.

[3] John J. Kruzel, "Official Hails Effect of Unmanned Aircraft on Warfare," *American Forces Press Service*, 25 March 2010, available at http://www.defense.gov/news/newsarticle.aspx?id=58479. In the words of one senior defense official, "It is difficult to find any other technology in the Department of Defense that in a single decade has made such a tremendous impact on the warfighting capability of the department" [Ibid].

U.S. military owned 90 unmanned aerial vehicles (UAVs).[4] By 2006, the number rose to approximately 3,000.[5] By 2010, the number surpassed 6,500.[6] Annual flight hours ballooned from 165,000 in 2006 to more than 550,000 in 2010, more than triple the number four years earlier.[7] Remarkably, the huge increase in unmanned operations hardly satisfied what former Secretary of Defense Robert Gates calls "insatiable demand" for unmanned aircraft.[8]

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[4] Office of the Secretary of Defense, "Unmanned Aerial Vehicles Roadmap: 2000-2025," April 2001, executive summary, available at http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA391358.

Definitional note: "The UAV is an aviation system that has as its centerpiece an uninhabited, reusable aircraft that sustains flight using onboard propulsion and aerodynamic lift. This definition excludes lighter-than-air crafts such as balloons, blimps, zeppelins, and airships; it rules out ballistic missiles, which do not employ aerodynamic lift; and it excludes standoff missiles, which, although closely related in forms like the cruise missile, are one-way, non-reusable platforms. The definition leaves open the issue of flight control and whether it is provided by a human through remote means, through a fully autonomous flight control system, or a hybrid of the two" [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, vi].

Note on terminology: in addition to UAV, four other terms are sometimes used to describe unmanned aircraft. These include "drone," "unmanned aircraft systems" (UAS), "remotely piloted vehicle" (RPV), and "remotely piloted aircraft" (RPA). In the 1940s and 1950s, unmanned aircraft were usually referred to as "drones" or "pilotless aircraft." The latter term was also used to describe missiles. By the 1960s, the term RPV came into fashion. UAV appeared in the 1980s. For a while, the "U" in UAV changed from "unmanned" to "uninhabited" before mutating back to "unmanned." In the 1990s, the U.S. military substituted UAS for UAV in recognition that the aerial vehicle constituted just one of the essential parts of the overall weapon system. To emphasize the point that unmanned aircraft require considerable aviation expertise to operate, in 2008 the U.S. Air Force went back to using the 1960's adjective "remotely piloted," only this time substituting "aircraft" for "vehicle." Thus, the U.S. Air Force's preferred acronym became RPA versus RPV, although the other services still refer to unmanned aircraft as UAVs or UASs. The Department of Defense (DoD) dictionary (available at http://www.dtic.mil) includes entries for RPV, UAV, and UAS, but not RPA.

[5] Dyke D. Weatherington, Testimony Before the United States House Committee on Oversight and Government Reform Subcommittee on National Security and Foreign Affairs, 23 March 2010, 4, available at http://oversight.house.gov/images/stories/Hearings/pdfs/20100323Weatherington.pdf. The Joint Unmanned Aircraft System Center of Excellence (JUAS COE) classifies unmanned aircraft into five groups. The inventory numbers cited only include UAVs in Groups 2-5. Specifics on the methodology employed by the JUAS COE to determine UAV groupings can be found in the "Joint UAS Concept of Operations," 2nd Edition, November 2008. UAVs in Group 1 include those that weigh twenty pounds or less or those that normally fly at or below 1,200 feet, such as the U.S. Army's Raven. UAVs in Group 2, those that weigh between 21-55 pounds, account for the majority of the inventory numbers. Nevertheless, UAVs in Groups 4 and 5, those weighing more than 1,320 pounds, have experienced significant growth and are increasingly competing with manned aircraft (see Chapter 6).

[6] Ibid.

[7] Ibid, 5. Similar to the inventory numbers, the flight hours cited only include hours flown by UAVs that the JUAS COE includes in Groups 2-5.

[8] Tu-Uyen Tran, "Demand for Unmanned Aircraft "Insatiable,'" *Air Force Times*, 11 June 2011, available at http://www.airforcetimes.com/news/2011/06/ap-demand-for-unmanned-aircraft-insatiable-061111. See also Lawrence Spinetta, "The Rise of Unmanned Aircraft: Do Earthbound Aviators Represent the Future of Aerial Warfare?" *Aviation History*, January 2011, 30. Robert Gates served as the 22nd United States Secretary of Defense from 2006 to 2011.

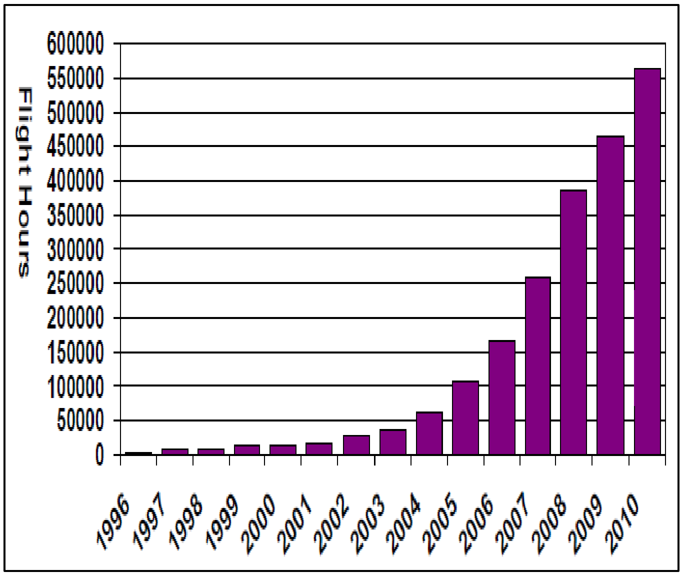

FIGURE 1 – U.S. Military Unmanned Aircraft Flight Hours (1996-2010)[9]

"This is an inflection point," predicted U.S. Air Force Chief of Staff General Norton Schwartz during congressional testimony in May 2009. "The trend lines are unmistakable that the United States Air Force will be an increasingly unmanned aviation service."[10] Four months later, Schwartz opined:

> Industry has already refueled an unmanned aircraft and demonstrated multi-aircraft control—all feats that only a few contemplated 10 years ago. It's not hard to imagine a multitude of other missions for our unmanned aircraft, including air transport, air refueling, suppressing enemy air defenses, forward air control, combat search and rescue, and more. It also is not difficult to imagine new operational concepts, such as groups of unmanned aircraft flying 'swarm' tactics.[11]

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[9] Dyke D. Weatherington, Testimony Before the United States House Committee on Oversight and Government Reform Subcommittee on National Security and Foreign Affairs, 23 March 2010, 5, available at http://oversight.house.gov/images/stories/Hearings/pdfs/20100323Weatherington.pdf.

[10] Statement of General Norton A. Schwartz, Chief of Staff, U.S. Air Force, in Senate, Committee on Armed Services, *Hearing to Receive Testimony on the Department of the Air Force in Review of the Defense Authorization Request for Fiscal year 2010 and the Future Years Defense Program*, 21 May 2009, 11, http://armed-services.senate.gov/Transcripts/2009/05%20May/09-35%20-%205-21-09.pdf.

[11] Norton Schwartz, "Future of Unmanned Aircraft" (remarks at the graduation ceremony for the Unmanned Aircraft System MQ-1 Predator Course, Creech Air Force Base, Nevada, 25 September 2009), 3-4, available at http://www.af.mil/shared/media/document/AFD-091001-013.pdf.

The rapid rise of unmanned aircraft gives the misleading impression that the weapon suddenly blossomed out of nowhere. In reality, unmanned aircraft technology dates back to the infancy of aviation itself.[12] Indeed, UAVs foundered as mere footnotes in aviation history for nearly a century before abruptly experiencing exponential growth, with no end in sight. That raises two questions: why now, and what can we anticipate for the future? This dissertation explores answers.

More broadly, it investigates when and why the U.S. military adopts new airpower-related weapons and then uses results from the study to speculate about the future of airpower. The topic is of critical importance to national security. New weapons have the potential to transform warfare. To the extent the United States adopts new combat arms that improve its war-fighting effectiveness and efficiency compared with rivals, it will likely retain its military advantage. "Right now, we're in the nineteen-teens relative to manned aircraft," observes one national security analyst.[13] If the analogy holds true, unmanned aircraft, like their

[12] The U.S. military first started tinkering with unmanned technology back in World War I. The U.S. Army built the "Kettering Bug," generally regarded as the first practical example of an unmanned aircraft, back in 1917. The Army staff developed plans to build 75 Bugs. The Army leadership sent then-Major "Hap" Arnold, at the time a young staff officer, to convince General John J. Pershing, the commander of the American Expeditionary Force, to employ the drone against Germany. Arnold fell ill, which delayed his meeting with Pershing, and the war ended before the Bug could make its combat debut. During World War II, the U.S. military purchased thousands of unmanned aircraft for use as anti-aircraft artillery practice targets. The Army and Navy also conducted limited experiments in which they packed old bombers with explosives, jerry-rigged the controls so they could be flown remotely, and attempted to crash them into enemy targets. During the Cold War, the U.S. military, in cooperation with the Central Intelligence Agency, built a number of unmanned spy planes. Most never made it beyond the prototype stage, a few saw very limited operational use, and only one, the "Lightning Bug" (see Chapter 5) was deployed in considerable numbers. The Lightning Bug, a derivative of the Firebee target drone, completed more than 3,000 reconnaissance sorties during the Vietnam War, although "completed" is a rather loose term since more than half of the 1,016 Lightning Bugs launched never returned. The program's abysmal mission success rate, coupled with its high costs as compared to the manned alternative, contributed to the Lightning Bug's cancelation shortly after the war ended. For a concise history of unmanned aircraft operations in the U.S. military, see Lawrence Spinetta, "The Rise of Unmanned Aircraft: Do Earthbound Aviators Represent the Future of Aerial Warfare?" *Aviation History*, January 2011.

[13] Peter Singer quoted in Don Parsons, "Air Force F-35s, Drones May Square Off in Budget Battle," *National Defense*, February 2012, available at http://www.nationaldefensemagazine.org/archive/2012/February.

manned equivalents during the twentieth century, may assume a dominant role in twenty-first century warfare.[14]

[14] Reflecting on how airplanes have influenced the twentieth century, Any Marshall, one of the most influential minds in U.S. defense circles, declared, "This century, and this century of warfare, has had at is center the idea of flying" [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 14].

CHAPTER 1

THINKING ABOUT WEAPON SYSTEM INNOVATION

"Rather than comparing [war] to art we could more accurately compare it to commerce, which is also a conflict of human interests and activities …"[15]

— *Carl von Clausewitz*

This chapter outlines the study's argument in four parts. First, it surveys literature on military innovation and explains why it insufficiently describes weapon system innovation.[16] Much of the literature on military innovation coalesces under three standard political science theories, those put forth by Barry Posen, Stephen Rosen, and Owen Coté.[17] Their theories respectively ascribe independent causal significance to three sets of relationships: civil-military, intraservice, and interservice.[18] Posen, Rosen, and Coté's theses, however, address doctrinal innovation, a related but different line of research than the focus of this study. Doctrinal innovation analyzes when and why military organizations make major changes in the way they

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[15] Carl von Clausewitz, *On War*, edited and translated by Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1989), 149.

[16] For a discussion of the origins of the term *weapon system*, see Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 4-6. Erhard states, "A weapon system is an identifiable (named) combat platform that integrates many intricate technologies and requires dedicated support equipment and specifically trained personnel. … Secretary of Defense James V. Forrestal pioneered the term *weapon system* in 1948" [Ibid, 4-5].

[17] Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman, "The Missing Transformation" in *US Military Innovation since the Cold War: Creation without Destruction*, Eds. Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman (New York, NY: Routledge, 2009), 7. Posen, Rosen, and Coté derive their theories from balance of power and organization theory, two political science perspectives that have achieved widespread currency in the study of national security policy [see discussion in Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 34-80].

[18] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 6.

fight, which may or may not include new weapons.[19] Weapon system innovation, on the other hand, always does. Nevertheless, this investigation argues that insights from their studies are relevant and insightful, although they incompletely identify the underlying sources of weapon system innovation.

Second, the chapter introduces a new, cross-disciplinary framework that merges insights from Posen, Rosen, and Coté's doctrinal innovation theories with ideas from diffusion of innovations (DOI) and business innovation research, adapted to fit a military context.[20] Posen and Rosen, even though they come to very different conclusions about who drives innovation and the pace at which it occurs (see next section), identify the same underlying driver of innovation: changes in a state's security situation.[21] Coté claims another factor, interservice competition, can also push the armed services to innovate. This dissertation recognizes that these two sources of innovation—the security environment and interservice competition—can play important roles in the adoption of new weapons, but it contends that Posen, Rosen, and Coté miss the most influential underlying variable: the perceived attributes of innovations. Based on a central finding of DOI research, the study hypothesizes that four perceived attributes—relative advantage, compatibility, trialability, and observability—of which relative advantage is the most important, account for the majority of the variance in whether and how

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[19] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 1.

[20] DOI theory addresses "the process in which an innovation is communicated through certain channels over time among the members of a social system" [Everett M. Rogers, *Diffusion of Innovations*. 5th ed. (New York: Free Press, 2003), 5]. It describes "regularities in the diffusion of innovations, patterns that have been found across cultures, innovations, and the people who adopt them" [Ibid, xvii-xviii].

[21] To be more precise, Rosen says "perceptions of change in the structure of the international security environment" is the underlying source of military innovation [Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 57]. Military leaders sense a change in the security situation, which leads them to adopt new doctrine. Similarly, Posen says changes in "the structure" of the international security situation spur civilian leaders to take action to force the military to adopt innovative doctrine [Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 36 and 239].

quickly new weapons are adopted.[22] Figure 2 groups the three factors that underlie and influence weapon system innovation—changes in a state's security situation, interservice competition, and the perceived attributes of innovations—under a concept called "willingness to cannibalize."[23]

[22] The hypothesis applies to large, complex technologies, which historians of technology often treat as a category unto itself.

[23] Rajesh Chandy and Gerard Tellis, two business innovation scholars, popularized the term "willingness to cannibalize." They define the term as the extent to which key decision makers are prepared to reduce the value of a firm's specialized investments [Rajesh K. Chandy and Gerard J. Tellis, "Organizing for Radical Product Innovation: The Overlooked Role of Willingness to Cannibalize," *Journal of Marketing Research* Vol. XXXV, November 1988, 475]. Specialized investments are either assets or organizational routines that lose value or become obsolete with the adoption of new technology [Ibid, 477]. Assets include both tangibles, such as specific equipment, and intangibles, such as knowledge and expertise; organizational routines refer to established procedures used to carry out day-to-day activities [Ibid]. The term "willingness to cannibalize" reflects the idea, first advanced by the economist Joseph Schumpeter, that innovation requires creative destruction: something new is accepted at the cost of something old [Joseph Alois Schumpeter, *Capitalism, Socialism and Democracy* (New York, NY: Harper & Brothers, 1942), 83]. Like industrial innovation, weapon system innovation also involves creative destruction. Harvey Sapolsky observes, "[Military] innovation therefore is not simply the adoption of new technology. It is the forceful abandonment of the old" [Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman, "The Missing Transformation" in *US Military Innovation since the Cold War: Creation without Destruction*, Eds. Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman (New York, NY: Routledge, 2009), 6]. Weapon system innovation can deliver new generations of an existing weapon system, or it can involve new classes of weapons (see section discussing *sustaining* and *disruptive* innovation later in this chapter).

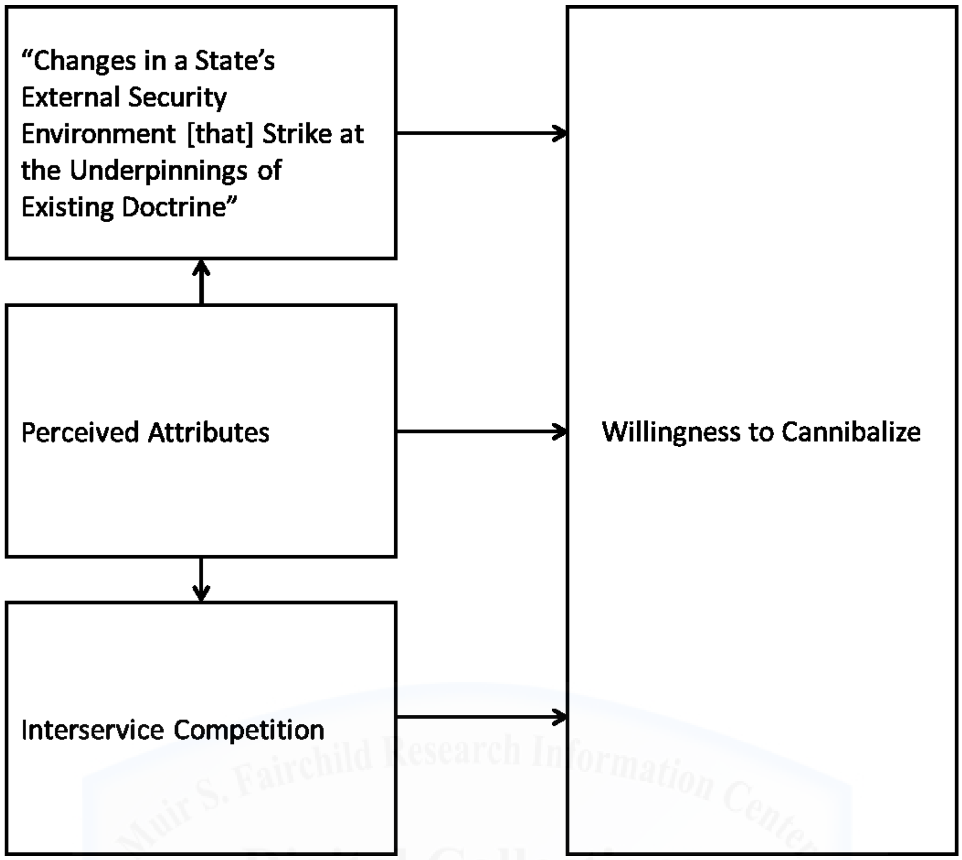

FIGURE 2 – The Underlying Sources of Weapon System Innovation[24]

One shortcoming of DOI research, however, is that it does not elaborate on how relative advantage evolves.[25] Fortunately, business innovation literature, most notably Harvard Business School professor Clayton Christensen's theory of disruptive innovation, points to a partial answer.[26] Christensen identifies two patterns in commercial innovation, which this

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[24] Owen Coté uses the phrase "changes in a state's external security environment [that] strike at the underpinnings of existing doctrine" to describe the singular factor that Stephen Rosen and Barry Posen identify as the underlying source of doctrinal innovation [Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 11-12].

[25] Ernest Burkman, "Factors Affecting utilization" in *Instructional Technology: Foundation*, Ed. Robert Mills Gagné (Hillsdale, NJ: Erlbaum, 1987), 442. See also Louis G. Tornatzky and Katherine J. Klein, "Innovation Characteristics and Innovation Adoption-Implementation: A Meta-Analysis of Findings," *IEE Transactions of Engineering Management*, Vol. EM-29, No. 1, February 1983, 34-35.

[26] Note: this dissertation is not the first to apply Christensen's ideas to military innovation. However, the vast majority of the literature that purportedly applies Christensen's ideas to military innovation does so in a way that has less to do with the substance of his analysis than its convenience as an evocative shorthand for vast technological, organizational, and cultural changes [Peter J. Dombrowski and Eugene Gholz, "Identifying Disruptive Innovation

study contends are also exhibited in weapon system innovation. The first pattern helps explain how innovations to existing weapons paradoxically delivers diminishing relative advantage with each generation, while the second describes a common pattern of adoption, which helps explain how new classes of weapons can blossom. Although these patterns differ between military and commercial contexts, they are nonetheless illuminating.[27]

Third, this chapter describes the study's method for testing whether the new, cross-disciplinary framework offers greater explanatory power than Posen, Rosen, and Coté's theories. To make the assessment, the dissertation investigates three cases: the adoption of the intercontinental ballistic missile (ICBM), the helicopter, and the UAV.

Fourth and last, the chapter outlines the remaining chapters of the dissertation and summarizes key findings.

Theory and the Defense Industry," *Innovations* Vol. 4, Issue 2, Spring 2009, 103]. For example, Vice Admiral Arthur Cebrowski, the first head of the Pentagon's Office of Force Transformation, as well as other Network Centric Warfare advocates, latched onto Christensen's disruptive innovation framework and used it to predict a wholesale transformation of the U.S. defense industrial base. Peter Dombroski and Andrew Ross, two Naval War College professors, along with Eugene Gholz, a professor at the University of Texas in Austin, evaluated this assertion in a research report titled *Military Transformation and the Defense Industry after Next: The Defense Industrial Implications of Network-Centric Warfare*. Two of the three authors of the report, Dombroksi and Gholz, parlayed the research project into a book, *Buying Defense Transformation: Technological Innovation and the Defense Industry*, and several articles on the same subject. *Warfighting and Disruptive Technologies: Disguising Innovation*, a book written by Terry Pierce, a naval officer, is the one exception. In it, Pierce borrows some of Christensen's concepts to explore when and why military organizations innovate. Specifically, he uses Christensen's ideas to "reformulate" Stephen Rosen's intraservice competition theory, one of three leading schools of thought on doctrinal innovation . Pierce concludes, as his title indicates, that disguising disruptive innovation as mere improvements in existing modes helps avert ruinous opposition from entrenched interests [Terry Pierce, *Warfighting and Disruptive Technologies: Disguising Innovation* (New York, NY: Frank Cass, 2004), 240]. While it may be wise for senior leaders who are intent on shepherding great change to use both caution and a bit of deception, Pierce did not need Christensen's framework to make that insight. In the sixteenth century, Niccolò Machiavelli, an Italian philosopher and diplomat, wrote, "… it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new." [Niccolò Machiavelli, *The Prince,* translated by W.K. Marriot, Ed. Randy Dillon (Plano, TX: Veroglyphic Publishing, 2009), 28]. Indeed, Pierce may have fared better had he left Christensen's theory completely out of his framework, as it seemed only to add confusion [Robert C. Rubel, Naval War College, book review, http://www.thefreelibrary.com/Pierce,+Terry+C.+Warfighting+and+Disruptive+Technologies%3A+Disguising...-a0142729016].

[27] Christensen's explanation for why these patterns occur in a commercial context is rooted in the motivations of for-profit companies seeking growth opportunities and thus, is not applicable in a military context.

POSEN, ROSEN, AND COTÉ

Despite differences, much of existing literature on military innovation coalesces under three standard political science theories, each of which offers a competing explanation for doctrinal change.[28] One theory, advanced by Barry Posen at the Massachusetts Institute of Technology (MIT), suggests that the armed services are unlikely to innovate on their own, and as a result, change comes through energetic civilian intervention.[29] Civilian leaders sense a change in the nation's security situation, become concerned about the nation's capability to respond militarily to a new threat, and subsequently force the military to adopt new doctrine.[30] When civilians intervene, Posen contends innovation proceeds swiftly.[31]

A second theory, championed by Stephen Rosen at Harvard, rejects Posen's hypothesis. Rosen argues that doctrinal innovation is driven internally within each of the services, not by civilians.[32] Furthermore, he insists innovation occurs gradually, not at the fast pace suggested

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[28] Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman, "The Missing Transformation" in *US Military Innovation since the Cold War: Creation without Destruction*, Eds. Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman (New York, NY: Routledge, 2009), 7.
[29] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 44-45.
[30] Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman, "The Missing Transformation" in *US Military Innovation since the Cold War: Creation without Destruction*, Eds. Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman (New York, NY: Routledge, 2009), 8.
[31] For example, after examining Great Britain's air defense policies between World War I and II, Posen argues that civilian intervention in 1937 prompted a dramatic shift from a bomber to fighter-centric acquisition strategy, a change he says provided the "underpinnings" for Britain's victory. Posen states: "Increasing threats by Germany, Italy, and Japan brought intensive civilian attention to military matters. … civilians refashioned the doctrine of the [Royal Air Force] … The civilians knew what they wanted and set about getting it … the development of an all-new military system [favoring fighters over bombers] was no accident [Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 175].
[32] [Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 18]. Rosen subdivides doctrinal innovation into peacetime and wartime categories. Unlike peacetime doctrinal innovations which he says are driven internally within each service, he suggests wartime innovations are, by necessity, a function of the development of new strategic measures of effectiveness [Ibid, 179]. After examining four cases of wartime innovation, he concludes, "The process of learning a new way of fighting began quickly enough, but simply took time to complete. The payoff came late in the war and was of limited value. … wartime innovation is so terribly difficult" [Ibid, 181-182].

by Posen. Indeed, Rosen claims doctrinal innovation takes place at a generational pace, proceeding "only as fast as young officers rise to the top."[33] Advocates of change find protectors and patrons, experiment doctrinally, and slowly climb the promotional ladder, contending with rivals for control over the direction of a military service.[34]

Owen Coté at MIT offers a third theory. He asserts military innovation is the product of interservice competition. Specifically, Coté claims interservice conflict leads the armed services to develop innovative military doctrine, while interservice cooperation suppresses innovation.[35] Although interservice competition involves those in uniform, Coté, like Posen, credits civilian leaders with being responsible for driving innovation. He claims "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services" is the overriding determinant of the competitive and cooperative patterns of service behavior.[36]

The following table provides a summary of the three schools of thought along four dimensions:

	Key Relationship	**Who Drives Innovation**	**Underlying Source of Innovation**	**Pace of Innovation**
Posen	Civil-Military	Civilians	Changes in a State's Security Situation	Fast
Rosen	Intraservice	Military	Changes in a State's Security Situation	Slow
Coté	Interservice	Civilians	Interservice Competition = Function (Civilian Management Style)	Fast or Slow

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[33] Ibid, 105.
[34] Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman, "The Missing Transformation" in *US Military Innovation since the Cold War: Creation without Destruction*, Eds. Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman (New York, NY: Routledge, 2009), 7.
[35] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 13 and 339-340.
[36] Ibid, 351. See also p. 339-340.

Relevant and Insightful, But Insufficient

Posen, Rosen, and Coté's theories address doctrinal innovation, a related but different line of research than the focus of this study. The subject differs from that examined in this dissertation because the dependent variable in their doctrinal innovation studies, as the name implies, is whether or not doctrinal change occurs, and doctrinal change does not necessarily require military organizations to adopt new weapons. For example, during World War II, the U.S. Navy directed its submarine captains to switch their focus from targeting Japanese warships to attacking enemy merchant shipping. The U.S. Navy's change in submarine doctrine did not involve the adoption of new weapons; rather, it changed how an existing weapon was employed.[37] Furthermore, technological change, by itself, does not necessarily mandate doctrinal change. Stated differently, the adoption of new weapons sometimes, but not always, correlates with doctrinal change. Military organizations can screw new weapons onto old doctrine.[38] For example, French air force doctrine remained stagnant between World War I and II despite the adoption of more advanced aircraft.[39] Indeed, neither Posen, Rosen, nor Coté assert technological shifts drive doctrinal change; nor do they explain how changes in doctrine translate into demand for new weapons.[40]

Nevertheless, pretext exists for applying insights from doctrinal innovation theory to help explain when and why the U.S. armed services adopt new airpower-related weapons. First, ambiguity in how Posen, Rose, and Coté define "military doctrine" and mixed messages in

[37] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 130.
[38] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 237.
[39] Ibid.
[40] Peter J. Dombrowski and Eugene Gholz, *Buying Defense Transformation: Technological Innovation and the Defense Industry* (New York, NY: Columbia University Press, 2006), 14.

their research leave open the possibility that the adoption of new combat arms could be considered a sub-category of the doctrinal-innovation field of study. In other words, the adoption of new combat arms can be viewed or defined as doctrinal innovation stimulated by changes or opportunities in technology. Second, two scholars, Thomas Ehrhard and Sean Frisbee, found evidence to suggest factors that shape doctrinal innovation also influence weapon system innovation.

Barry Posen asserts "military doctrine" answers two questions: (1) what means shall be employed, and (2) how shall they be employed?[41] Logically, the adoption of new classes of weapons would seem to qualify as a change in means, and hence constitute a change in doctrine, but he concludes otherwise, claiming that the adoption of new weapons has little influence on doctrine.[42] Posen, however, makes a fundamental assumption in his research approach that seems to contradict this conclusion. He states, "Military doctrine, particularly the aspects that relate directly to combat, is strongly reflected in forces that are acquired by the military organization. Force posture, the inventory of weapons any military organization controls, can be used as evidence to discover military doctrine."[43] Based on that statement, a change in force posture would seem to imply a change in doctrine.

Like Posen, Owen Coté bases his thesis on the same assumption. In fact, Coté repeats Posen's words verbatim.[44] Accordingly, Coté's research approach seems to imply that he would

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[41] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 13.
[42] Posen concludes technology has a weak and indirect effect on doctrine [Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 239].
[43] Ibid, 14.
[44] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 8.

consider a change in force posture to qualify as a change in doctrine.[45] But, the conclusions he draws from studying the U.S. Navy's adoption of sea-launched ballistic missiles indicate he does not consider the adoption of new weapons, per se, to qualify as a doctrinal innovation. Coté alleges the U.S. Navy's adoption of the Polaris represented a doctrinal change, yet its adoption of the Trident II did not.[46]

Stephen Rosen, citing the advice of unnamed experts, attempts to differentiate between doctrinal and technological innovation.[47] He says doctrinal innovation involves a change in one of the primary combat arms of an armed service, or alternatively, the creation of a new combat arm.[48] In contrast, he defines technological innovation as "building new machines," which he contends is the "business of military research and development (R&D) communities."[49] Indeed, Rosen uses the term R&D as shorthand for technological innovation.[50] Considering Rosen's definitions for doctrinal and technological innovation, the adoption of new classes of weapons, such as the U.S. Air Force's adoption of the ICBM and unmanned aircraft, would seem to qualify as both doctrinal and technological innovation. Curiously, however, Rosen addresses the ICBM and unmanned aircraft in the section of his book that covers

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[45] Coté states, "Military doctrine is the chosen combination of people, technology, and tactics that characterizes a military organization or service" [Ibid, 42]. Furthermore, he observes that "certain types of weapon systems become the technological centerpiece of a military organization's doctrine" [Ibid, 50]. Hence, a change in technology would often times seem to imply a change in doctrine.

[46] Ibid, abstract.

[47] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 5. See also p. 40.

[48] Ibid, 7.

[49] Ibid, 185. Most scholars who examine technological innovation take the same narrow approach as Rosen, strictly studying the topic from an R&D perspective. For example, Thomas Lassman explores the role of department of defense laboratories in developing novel weapons [Thomas C. Lassman, *Sources of Weapon Systems Innovation in the Department of Defense: The Role of In-House Research and Development, 19445-2000* (Washington, DC: Center of Military History, United States Army, 2008)]. Others offer historical narratives on the topic but do not offer a framework to explain the phenomenon. For example, see Wilbur D. Jones, *Arming the Eagle: A History of U.S. Weapons Acquisition Since 1775* (Fort Belvoir, VA: Defense Systems Management College Press, 1999).

[50] Ibid, 185.

technological innovation, yet he explores other conceptually novel weapons, such as the aircraft carrier and the helicopter, in chapters devoted to doctrinal innovation. He offers no explanation as to why he considers the ICBM and unmanned aircraft, as implied by the section of the book in which he addresses those innovations, to be "purely technological" innovations.[51] Frustratingly, despite acknowledging that any study of military innovation that ignores technological innovation would hardly be complete, Rosen fails to offer a hypothesis as to what drives military organizations to build and adopt new weapons, except to suggest it does not seem to be a function of intelligence on what the enemy is building.[52] As a result, the reader is left to wonder whether factors that Rosen identifies as drivers of doctrinal innovation also apply to the development and adoption of new weapons. Clearly, there is more to the story of the adoption of the ICBM (see Chapter 3) and unmanned aircraft (see Chapter 5) than just chalking them up to R&D.

Regardless of whether the adoption of new classes of weapons qualifies as a sub-category of the doctrinal innovation research, a posteriori justification exists for applying insights from doctrinal innovation theory to explain weapon system innovation since two scholars found evidence to suggest doctrinal innovation research informs weapon system innovation. Thomas Ehrhard incorporates insights from Posen, Rosen, and Coté's doctrinal innovation models, as well as ideas from innovation theories in other fields of study, into a framework that he uses to investigate whether the four U.S. military services developed UAVs

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[51] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 185.
[52] Ibid, 8. See also pages 185-220. Rosen offers a prescriptive strategy for managing R&D. He recommends funding many different technologies to the point of procurement, but then deferring large-scale production while uncertainties are resolved [see pages 243-250].

in distinct ways.[53] After examining the history of more than twenty UAV programs from 1955-2000, Ehrhard arrives at three major conclusions.[54] First, during those forty-five years, he suggests the armed services were the dominant forces in UAV development, an idea that supports Rosen's hypothesis.[55] Second, he finds, in line with Posen's theory, that outside agencies stimulated UAV interest within the services when they served as risk-taking surrogates for the services or promoted the services' unique functional requirements, but dampened, and in some cases, poisoned service interest in UAVs when they skewed development requirements too far from individual service needs.[56] Third, Ehrhard concludes external environmental influences, chiefly the immaturity of key supporting technologies, limited the armed services' interest in adopting UAVs.[57] The finding is important because it suggests, unlike Posen's allegation that technology has little influence on doctrinal change, that it can be an important variable in weapon system innovation. In addition to his three major findings, Ehrhard also observes that interservice rivalry played a role in the U.S. Air Force's bid to take over the Predator prototype program from the U.S. Army, evidence that supports Coté's theory.[58]

A limitation of Ehrhard's study, however, is that he completed it in 2000, before unmanned aircraft experienced exponential growth (see Figure 1, Introduction). In that regard, his thesis does not necessarily explain weapon system innovation, rather the lack of it.[59]

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[53] Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 2.
[54] Ibid, 570-1.
[55] Ehrhard states, "... weapon systems and the military organizations that operate them are the essential components of the weapon system innovation process" [Ibid, 630]. Accordingly, Ehrhard's study represents an extension of Rosen's thesis [Ibid].
[56] Ibid, 570-1.
[57] Ibid.
[58] Ibid, 599.
[59] Ehrhard observes, "… Rosen argued that internal structural change in the form of a new 'combat arm' formed the basis for an innovation's organizational maturity. *While this has not occurred with UAVs*, the varying explanations

Ehrhard chronicles why UAVs, in his words, "fell into a no-man's land between risk and reward, requirements and costs, the services and their civilian masters, and different service subgroups."[60]

In 2004, just as UAVs were starting to witness exponential growth, Sean Frisbee, under Ehrhard's tutelage, analyzed factors that led the U.S. Air Force to arm the Predator.[61] Frisbee assumes military innovation is unique, which led him to strictly confine the scope of his literature search to models that pertain specifically to the profession of arms.[62] As a result, he considers only three, those put forth by Posen, Coté, and Rosen. While the assumption explains the limited scope of his literature search, it does not necessarily justify his application of doctrinal innovation theory to his selected case, one that seemingly constitutes, at least under Rosen's definitions, a technological rather than a doctrinal innovation. Indeed, Frisbee never suggests that the adoption of the Predator, let alone arming it, represents doctrinal innovation. Nevertheless, he applies Posen, Coté, and Rosen's doctrinal theories to the case.

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for why it has not happened nevertheless paint a picture of service diversity and internal dynamism …" [emphasis added] [Ibid, 631].

[60] Ibid, 634.

[61] Sean Frisbee, "Weaponizing the Predator UAV: Toward a New Theory of Weapon System Innovation," School of Advanced Air & Space Studies Monograph, June 2004, abstract.

[62] Frisbee states, "Although many authors have written about innovation in general, only three [Posen, Coté, and Rosen] have developed models that focus on military innovation" [Ibid]. Later in his monograph, he describes why he did not consider innovation models developed in other fields of study: "Although military innovation shares many attributes with other types of innovation, it differs on some fundamental levels. … Innovating in one venue is not necessarily easier than the other one, but the driving forces behind the innovation are often fundamentally different. For this reason, this inspection of the innovation literature focuses on those innovation models that pertain specifically to the profession of arms" [Ibid, 9]. Frisbee's decision to limit his literature survey to Posen, Coté, and Rosen is curious since their theories are derived from political science. Why would political science apply to military innovation while insights from others social sciences do not? The seemingly innate bias among military scholars against learning from other fields, particularly economic and business literature, is illogical. Political science pilfered organizational theory, which is part and parcel to Posen, Coté, and Rosen's research, from economists [Terry Moe, "The Politics of Structural Choice: Toward a Theory of Public Bureaucracy" in *Organization Theory: From Chester Barnard to the Present and Beyond*, Ed. Oliver E. Williamson (New York, New York: Oxford University Press, 1995), 116].

Frisbee finds that the standard political science theories, when considered individually, are insufficient, but when assessed collectively, provide more explanatory power.[63]

In arriving at that conclusion, Frisbee circumvents a dilemma: the leading doctrinal theories are a disparate collection of contradictory theories, which makes assessing their collective explanatory power conceptually challenging. Rosen positions his argument as the antithesis of Posen's thesis in terms of two critical aspects of innovation: (1) who drives innovation and (2) the pace at which it occurs.[64] Consequently, at least one of the two theories will wrongly explain what actually took place and/or will incorrectly predict what will happen for any given innovation. Coté makes no attempt to mediate between Posen and Rosen's diametrically opposed arguments or to suggest when one theory dominates over the other. Instead, he asserts his model of innovation can trump the two put forth by Posen and Rosen.[65] Frisbee's solution to the dilemma, which he markets as a prescription for practitioners to harvest more explanatory power from existing theory, is to examine innovation through the lens of all three models and then use John Kingdon's adaptation of the "garbage-can model" as a framework to integrate the analysis.[66] Although Frisbee's approach makes a substantial

[63] Ibid, 84.
[64] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 10-18.
[65] Coté declares, "I argue that when there is intense interservice conflict, doctrinal innovation can occur even in the face of strong civilian and intraservice opposition. Likewise, when the need to preserve interservice cooperation is strong, innovative doctrines can be suppressed even when they have strong civilian and intraservice support" [Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 13].
[66] Michael D. Cohen, James G. March, and Johan P. Olsen originally developed the "garbage can model" of organizational decision-making, which they described as "…a collection of choices looking for problems, issues and feelings looking for decision situations in which they might be aired, solutions looking for issues to which they might be the answer, and decision makers looking for work" [Michael D. Cohen, James G. March, and Johan P. Olsen, "A Garbage Can Model of Organizational Choice," *Administrative Science Quarterly* 17, 1972, 2]. John Kingdon adapted the theory to public policy, explaining how changes in policy are a function of the interaction of three streams: the problem stream, the policy stream, and the political stream, which move independently through the policy system [John W. Kingdon, *Agendas, Alternatives, and Public Policies*, 2nd ed. (New York, NY: Longman

contribution to the understanding of weapon system innovation, it represents, as he acknowledges, a first attempt at integrating and applying Posen, Coté, and Rosen's disparate insights to weapon system innovation.[67]

A NEW CROSS-DISCIPLINARY THEORY

More accurately explaining weapon system innovation, as revealed by the cases examined in Chapters 3 through 5, requires building a model that offers more than just the sum of the parts of existing doctrinal innovation theory. To add explanatory power, this study develops a framework that incorporates research from other innovation fields.

Everett Rogers, the scholar whose work established DOI as a field of study, concludes that the perceived attributes of any innovation are, in general, the most influential factor in whether and how quickly it is adopted.[68] He divides the perceived attributes of an innovation into the following five characteristics, which he says explain between 49 and 87 percent of the variance in whether and how quickly an innovation gets adopted:[69]

Press, 2003), 1]. For a brief history of the garbage can model and its adaptations, see Jonathan Bender, Terry M. Moe, and Kenneth W. Shotts, "Recycling the Garbage Can: An Assessment of the Research Program," *American Political Science Review* 95, March 2001, 169-190.

[67] Sean Frisbee, "Weaponizing the Predator UAV: Toward a New Theory of Weapon System Innovation," School of Advanced Air & Space Studies Monograph, June 2004, 89.
First, Frisbee examines only one case. Moreover, the case he selects ostensibly focuses on one service, the U.S. Air Force. Second, by limiting his inspection of innovation literature to just Posen, Coté, and Rosen's models, Frisbee misses the opportunity to inform his framework with innovative ideas from related fields of study.

[68] DOI theory addresses "the process in which an innovation is communicated through certain channels over time among the members of a social system" [Everett M. Rogers, *Diffusion of Innovations*. 5th ed. (New York: Free Press, 2003), 5]. It describes "regularities in the diffusion of innovations, patterns that have been found across cultures, innovations, and the people who adopt them" [Ibid, xvii-xviii].

[69] Everett M. Rogers, *Diffusion of Innovations*. 5th ed. (New York: Free Press, 2003), 221.

(1) *Relative Advantage* refers to the expected value (EV) of an innovation as compared with alternatives.[70] In mathematical terms, EV equals anticipated payoff times the probability of receiving that payoff. In other words, EV represents an innovation's payoff discounted for uncertainty. The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption.[71]

(2) *Compatibility* is the degree to which an innovation is perceived as being consistent with existing norms and values, past experiences, needs of potential adopters, routines, previously adopted ideas and technology, etc.[72] The more compatible a new technology or idea is, the more rapid its rate of adoption. The adoption of an incompatible innovation often requires the prior adoption of a new value system, which usually is a relatively slow process.

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[70] Rogers offers varying definitions for the term "relative advantage." In general, he says relative advantage represents the degree to which an innovation is perceived as better than the technology it supersedes [Ibid, 15 and 229]. Later, he refines the term, defining it as a ratio of the expected benefits and costs of adopting an innovation [Ibid, 233]. In economics, the term "anticipated payoff" refers to net benefits (i.e., benefits minus costs), which calculated slightly differently than Roger's ratio. Nevertheless, both measures perform the same task—cost-benefit analysis. In this case, the difference between the two calculations is meaningless since Rogers does not offer his definition of relative advantage with the intent of performing precise mathematical calculations. Instead, his intent is to highlight that the likelihood of adoption increases commensurate with the degree to which benefits outweigh costs. Likewise, the intent of this study is not to produce precise mathematical computations, but as a guiding concept. Tweaking Rogers's definitions of the term relative advantage to explicitly incorporate uncertainty, and thus make it synonymous with expected value, a term whose origins lie in statistics and economics, captures a recurring theme in Rogers's seminal book: the idea that uncertainty plays a central role in the adoption or rejection of innovations. For example, he states, "The innovation-decision process … consists of a series of choices and actions over time through which an individual or a system evaluates a new idea and decides whether or not to incorporate the innovation into ongoing practice. This behavior consists essentially of dealing with the uncertainty that is inherently involved in deciding about a new alternative" [Ibid, 168. See also pages xx, 6, 1, 14, 16, 44, 46, and 49, among others]. Similarly, in the section of his book titled, "Relative Advantage and Rate of Adoption," Rogers notes, "Throughout this book we have emphasized that the diffusion of an innovation is an uncertainty reduction process" [Ibid, 232]. Although Rogers does not necessarily include uncertainty in his definitions of relative advantage, he does incorporate it into his discussions of specific innovations. For example, he states, "The relative advantage of preventive innovations is difficult for change agents to demonstrate to their clients, because the advantages occur at some future and unknown time, and may not happen at all" [Ibid, 233].

[71] Ehrhard's analytical framework includes UAV effectiveness and efficiency, which he respectively defines as relative military utility and relative utility per cost [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 17].

[72] Everett M. Rogers, *Diffusion of Innovations*. 5th ed. (New York: Free Press, 2003), 240.

(3) *Trialability* is the degree to which an innovation may be experimented with on a limited basis.[73] New ideas that can be tried and tested on a trial basis and shown to succeed are more likely to be adopted.

(4) *Observability* is the degree to which the results of an innovation are visible. The more visible the results of an innovation, the more likely it is to be adopted.[74]

(5) *Complexity* is the degree to which an innovation is perceived as difficult to understand and use.[75] New ideas and technology that are easier to understand and operate are adopted more rapidly.

Rogers acknowledges that all the attributes on his list may not be influential in every context. Indeed, one of the attributes in his list—complexity—has little influence on the adoption of new weapons.[76] Military organizations do not necessarily shy away from complex weapons. On the contrary, state-of-the-art technology that pushes the envelope of what is possible is an attractive quality because it provides incumbents more of what they want, delivering greater performance with each generation.[77]

Before describing the two patterns that Clayton Christensen identifies in his research that are useful in analyzing how the relative advantage of weapons evolves, it is helpful to first define, in a military context, two terms coined by Christensen that differentiate types of

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[73] Ibid, 16.
[74] Ibid.
[75] Ibid.
[76] Ibid.
[77] "In the Pentagon, 'simple' is a bad word because it implies cheap," remarks William Lind. "The Pentagon is not a military headquarters; it is a bank. Its main mission is to add to the money flow. Simple systems do that poorly" [William S. Lind, "Droning On," *The American Conservative*, September 2009, available at http://www.amconmag.com/article/2009/sep/01/00016].

innovation.[78] *Sustaining innovation* delivers ever-more-perfected versions of the same weapon. Each generation offers better performance than what was previously available, but retains the same classic form.[79] Essentially, it entails making a better mousetrap, offering better performance than what was previously available.[80] The five generations of fighter jets exemplify unbroken cycles of sustaining innovation (see Figure 3).[81] The world's first operational jet fighter, the Messerschmitt 262 (Me-262), was introduced at the end of World War II. Despite more than sixty years of development, only experts and enthusiasts would immediately categorize the Me-262 as anything other than a contemporary fighter.[82] In

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[78] Clayton M. Christensen, *Innovator's Dilemma*, First Collins Business Essentials ed. (New York, NY: HarperCollins, 2006), xviii. See Chapter 2 for a more detailed discussion of these two terms. In a military context, others have used "disruptive innovation" and related terms in a way that refers to game-changing technologies that have the potential to marginalize United States military technological superiority, potentially threatening the balance of power between the United States and its rivals. For example, a *Joint Force Quarterly* article defines a "disruptive challenge [as] a challenge from adversaries who seek to develop and use breakthrough capabilities to negate current U.S. military advantages in key operational domains" [Terry J. Pudas, "Disruptive Challenges and Accelerating Force Transformation," *Joint Forces Quarterly* 42, 3rd Quarter 2006, 44]. Another author defines a "disruption technology [as] a technology that causes disarray or increases fog of war for an adversary" [Samuel T. Mitchell II, "Identifying Disruptive Technologies Facing the United States in the Next 20 Years," U.S. Army Command and General Staff College Monograph, November 2009, 3]. The 2004 National Security Strategy (NSS) of the United States observes, "Disruptive challenges may come from adversaries who develop and use breakthrough technologies to negate current U.S. advantages in key operational domains" [available at http://www.defense.gov/news/mar2005/d20050318nms.pdf]. The 2006 NSS states, "Disruptive challenges from state and non-state actors who employ technologies and capabilities (such as biotechnology, cyber and space operations, or directed energy weapons) in new ways to counter military advantages the United States currently enjoys" [available at http://www.comw.org/qdr/fulltext/nss2006.pdf]. Similarly, the 2008 NSS writes, "Our adversaries … may develop disruptive technologies in an attempt to offset U.S. advantages" [available at http://www.defense.gov/news/2008%20national%20defense%20strategy.pdf].

[79] Edward N. Luttwak, "Breaking The Bank: Why Weapons Are So Expensive," *American Interest,* September-October 2007, http://www.the-american-interest.com/article.cfm?piece=323.

[80] Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution* (Boston, MA: Harvard Business School Press, 2003), 40.

[81] For a breakout of characteristics that define each generation of fighter aircraft, see Deloitte Consulting, "Can we afford our own future? Why A&D programs are late and over-budget — and what can be done to fix the problem," 2009, 5, http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/US_AD_CanWeAffordOurOwnFuture_0127.pdf.

[82] Ibid. The quest to build battleships with bigger, more-accurate guns and thicker armor provides another example. In 1861, HMS Warrior's guns weighed 4.1 tons and fired a 110-pound shell. By 1906, HMS Dreadnought's deck bristled with guns that weighed 57.7 tons that fired 850-pound shells. Of course, bigger guns and more armor necessarily meant bigger battleships. Between 1850 and 1940, the size of the average battleship grew by nearly 900%. In 1850, the average battleship displaced 7,000 tons, whereas by the start of World War II, that figure jumped to over 60,000 tons [George and Meredith Friedman, *The Future of War: Power, Technology & American World Dominance in the 21st Century* (New York, NY: Crown Publishers, 1996), 168-169]. Ultimately, the last

contrast to sustaining innovation, *disruptive innovation* involves new classes of weapons.[83] The aircraft carrier's displacement of the battleship as the U.S. Navy's dominant capital ship provides one such example.

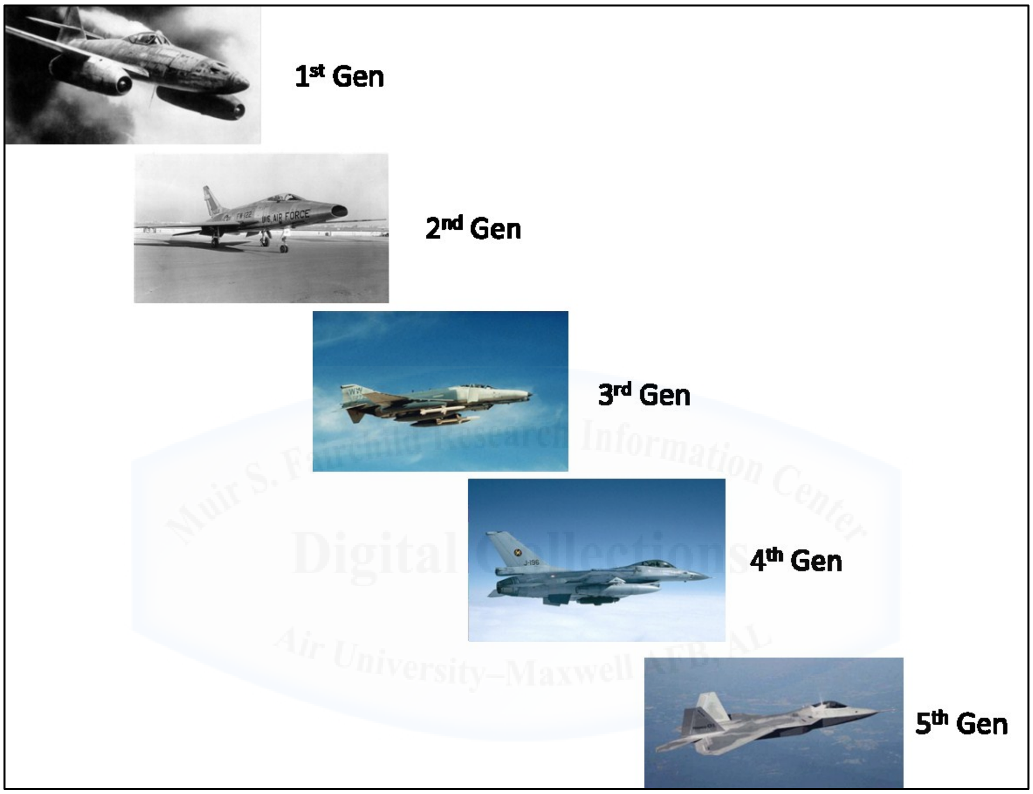

FIGURE 3 – An Example of Sustaining Innovation: Five Generations of Fighter Jets

(From Top to Bottom: Me-262, F-100, F-4, F-16, & F-22)

Christensen argues that incumbent commercial firms habitually pursue sustaining innovations, improving the performance of established products along dimensions of

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generation of battleships featured deck guns with the ability to lob mammoth shells at targets twenty miles away. Moreover, they achieved accuracy within 200 yards of their aim point [Terry Pierce, *Warfighting and Disruptive Technologies: Disguising Innovation* (New York, NY: Frank Cass, 2004), 13].

[83] The term "classes of weapons" refers to a level of aggregation above that of a major weapon system (MWS). JP 1-02, *The Department of Defense of Military and Associated Terms* (amended 9 June 2004) defines a major weapon system as "one of a limited number of systems or subsystems that for reasons of military urgency, criticality, or resource requirements, is determined by the Department of Defense as being vital to the national interest."

performance that mainstream customers in major markets have historically valued.[84] Likewise, the armed services, because of their strong attachment to existing weapon systems, also consistently pursue sustaining innovations. Secretary of Defense Robert Gates alluded to the presence of this pattern in a military context and called attention to its consequences during a 2009 speech. Gates lamented, "The perennial procurement and contracting cycle–going back many decades–of adding layer upon layer of cost and complexity onto fewer and fewer platforms that take longer and longer to build must come to an end."[85] A year later, Gates revisited this theme during remarks, appropriately enough, at the Eisenhower Presidential Library and Museum in 2010:[86]

> If nature takes its course, major weapons programs will devolve into pursuing the limits of what technology will bear without regard to cost or what a real world enemy can do – a process that over the past two decades has led to $20 million howitzers, $2 billion bombers, and 3 to 6 billion dollar destroyers. And when costs soar, the number of ships and planes the military can buy drops accordingly. For example, the Navy wanted 32 of the next generation destroyer – the DDG-1000; because of skyrocketing costs, we will build three. The Air Force wanted 132 B-2 bombers; at $2 billion each, we built 20. This is unsustainable.[87]

The perennial pursuit of sustaining innovations, what Gates referred to as nature taking its course, can lead to ripe conditions for the adoption of disruptive innovation. Two reasons prevail. First, uninterrupted cycles of sustaining innovations, at some point, paradoxically produce new generations of weapons with diminishing relative advantage. Although sustaining

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[84] Clayton M. Christensen, *Innovator's Dilemma*, First Collins Business Essentials ed. (New York, NY: HarperCollins, 2006), xviii.
[85] Robert M. Gates, "Defense Budget Recommendation Statement" (speech, Arlington, VA, 06 April 2009), http://www.defense.gov/speeches/speech.aspx?speechid=1341.
[86] In his farewell speech, President Dwight Eisenhower warned against "the acquisition of unwarranted influence" by the military industrial complex. Eisenhower advocated for "balance between cost and hoped for advantage -- balance between the clearly necessary and the comfortably desirable." A transcript of Eisenhower's farewell speech is available at http://www.h-net.org/~hst306/documents/indust.html.
[87] Robert M. Gates, "Eisenhower Library (Defense Spending)" (speech, Eisenhower Library, Abilene, KS, 08 May 2010), http://www.defense.gov/speeches/speech.aspx?speechid=1467.

innovation results in cutting-edge technological advances, the corresponding increase in cost and complexity associated with those improvements can make new generations of the same weapon system less cost-efficient for all but the most demanding applications. For example, no one questions whether a B-2 is more capable than, say, a B-52, but the issue becomes whether the difference in capability costs more than it is worth. The perennial pursuit of sustaining innovations can provide an increasing incentive for stakeholders, especially those who are not served well by existing weapons, to explore and embrace alternatives. Moreover, sustaining innovations can lead to a narrower appeal, which lessens the ability of the subculture that champions the existing weapon system to compete for resources in the future. To be clear, the pattern does not guarantee the adoption of disruptive new classes of weapons, but it can be an important factor that influences perceptions of the relative advantage offered by existing ones. Second, because sustaining innovation often leads to fewer systems being acquired with each generation, it tends to naturally erode the ranks and status of the subculture that derives its identity and power from a mature weapon system.

Christensen's research identifies a second pattern that also characterizes weapon system innovation. He suggests that disruptive innovations tend to follow a common pattern of adoption; they typically underperform, at least initially, when judged against existing products, but offer benefits that appeal to those not served well by sustaining innovations.[88] Disruptive innovations tend to provide "good enough" capability for low-end users and/or offer a whole new population access to a capability it previously did not enjoy. As a result, the disruptors often take root serving secondary, fringe, or niche markets and then blossom with time to

[88] Clayton M. Christensen, *Innovator's Dilemma*, First Collins Business Essentials ed. (New York, NY: HarperCollins, 2006), xv.

encroach on mainstream markets.[89] The equivalent in a military context is for new classes of weapons to first fulfill peripheral roles and then graduate to core missions, progressively displacing existing weapon systems commensurate with the rate at which their relative advantage evolves.[90] Intriguingly, Christensen repeatedly lists unmanned aircraft as an example of a disruptive innovation following this path, although his assertion seems to be based on a casual observation rather than extensive analysis.[91]

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[89] Ibid.

[90] Unlike existing military innovation theory that offers conflicting and binary descriptions of the pace of innovation (i.e., fast or slow), the pattern that Christensen identifies accommodates changing rates of adoption over time, a characteristic required for accurately describing the pace of weapon system innovation. Rarely, if ever, does weapon system innovation proceed at a constant speed, which means existing military innovation theories are, at best, accurate only for a single point in time. Posen, Rosen, and Coté's failure to accommodate changing rates of adoption over time is particularly surprising since innovation scholars in a wide range of academic disciplines have long recognized innovation does not follow a single speed. More than two hundred years ago, French sociologist Gabriel Tarde pointed out "invention or discovery," the term he used to describe innovation, follows three distinct phases: "a slight incline, a relatively sharp rise, and then a fresh modification of the slope until the plateau is reached" [Gabriel Tarde, *The Laws of Imitation*, translated by Elsie Clews Parsons (New York, NY: Henry Holt and Company, 1903), 127]. Note: A George Washington University PhD dissertation written by John Davis picks up on the idea that innovative weapon systems performing peripheral missions offer huge potential. He concludes, "The Department could realize considerable operational benefits by enacting policies designed to improve oft-neglected peripheral missions" [John H. Davis, "Theater Airborne Reconnaissance: A Peripheral Military Mission's Innovation," George Washington University Dissertation, June 2007, abstract].

[91] Ibid, xxix. See also Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution* (Boston, MA: Harvard Business School Press, 2003), 48 and 64. Christensen and Raynor state, "These machines took root as drone targets to uncover hidden anti-aircraft emplacements. They then moved up-market into surveillance roles, and in the 2001-2002 war in Afghanistan, moved for the first time into limited weapons-carrying roles" [p. 64]. Their chronology neglects unmanned aircraft's history before World War II (see earlier footnote). Moreover, it incorrectly outlines the sequence of missions that UAVs have progressively fulfilled. During World War II, their principal use was in providing anti-aircraft artillerymen with practice targets, not to discover hidden anti-aircraft emplacements. The confusion in asserting that they helped "uncover hidden anti-aircraft emplacements" may have come from the fact that a few jerry-rigged manned bombers, packed with explosives and converted into remote-controlled flying bombs, were crashed into targets, including anti-aircraft emplacements. During the Vietnam War, Lightning Bug surveillance drones snapped pictures of highly defended targets, helping to locate enemy surface-to-air missile (SAM) sites. The Lightning Bug was developed from the Ryan Model 147 Firebee, a drone originally used for target practice. The drone morphed into well over a dozen different versions, expanding its repertoire of missions beyond reconnaissance. Several variants of the Lightning Bug were developed to carry specialized signals intelligence packages, including one "SAM sniffer" version, the Model 147E. That particular drone was sent on multiple missions over North Vietnam to collect the launch signal of the Soviet-designed SA-2 surface-to-air missiles, a mission too dangerous for a manned aircraft. Many were destroyed, but not before they relayed the vital electronic intelligence to another platform orbiting nearby. From this data, the United States was able to develop a warning system for manned fighters and bombers alerting aircrew when an SA-2 missile launch was imminent. Additionally, the data helped the United States to develop jamming pods that provided electronic countermeasures to the SA-2, reducing the system's lethality. See Lawrence Spinetta, "The Rise of Unmanned Aircraft: Do Earthbound Aviators Represent the Future of Aerial Warfare?" *Aviation History*, January 2011.

While this dissertation recognizes that disruptive military innovation can follow any number of paths to adoption, Christensen's claim seems to match not only the adoption pattern, to date, of unmanned aircraft, but also the adoption of other airpower-related innovations, such as manned fixed-wing and rotary-wing aircraft. Moreover, Christensen helps explain how disruptive innovation can overcome resistance from dominant constituencies wedded to existing weapon systems. Entering service in secondary roles can allow disruptive technologies to demonstrate their worth before they are perceived as threats to the existing weapons system. Taking root performing secondary roles means that disruptive innovations may not necessarily compete, at least initially, with existing weapons that define a military organization's essence. In fact, the adoption of disruptive systems can complement and improve the effectiveness of existing weapons. For example, aircraft, at first, did not compete directly with battleships. The U.S. Navy employed early aircraft as airborne scouts and artillery spotters, which helped improve the effectiveness of its battleships. Similarly, the RQ-1 Predator, the breakout UAV that launched the apparent on-going revolution in airpower, did not compete directly against high-tech manned aircraft like the F-15 or F-16, which are designed for high-end combat missions in major wars.[92] Rather, it demonstrated utility locating targets for manned aircraft while performing persistent surveillance, a monotonous and dull low-end mission that champions of manned aircraft did not covet.[93] The lowly propeller-driven drone, which was literally powered by a four-stroke snowmobile engine, fulfilled a much-

[92] The evolution of the Lightning Bug highlights this same pattern of evolution (or march "up-market"). See previous footnote.

[93] Traditionally, the reconnaissance mission has been valued far less than force application (i.e., combat missions that involve killing the enemy). Although it marks the original purpose of military aviation, reconnaissance ranks near the bottom, if not last, among an informal hierarchy of missions among war fighters [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 87].

needed, but not indispensable niche mission, allowing it to gain a foothold in the U.S. Air Force, a service whose technological zeal traditionally favors faster, higher-flying, longer-ranged, and manned jet aircraft.[94]

RESEARCH APPROACH

To test whether the new, cross-disciplinary framework offers greater explanatory power than Posen, Rosen, and Coté's theories, this dissertation investigates the U.S. military's adoption of three new classes of weapons: the intercontinental ballistic missile (ICBM), the helicopter, and the UAV. (Note: the focus of the investigation is on the apparent, on-going unmanned revolution in airpower, and it uses the first two cases to inform and to provide insights into the future outcome of the third.)

Why explore these three cases and not others? First, examining the adoption of the ICBM, helicopter, and UAV affords the opportunity to revisit cases that Posen, Rosen, and Coté cite as justification for their theories, hence facilitating a comparison of the proposed model with competing explanations. Second, there is perhaps no better way to understand the likely outcome of the apparent on-going technological shift in airpower than studying the lineage of airpower-related innovations leading up to and including the rapid growth of UAVs. The ICBM, helicopter, and UAV cases constitute threads of an interrelated narrative that arguably addresses the most important airpower-related classes of weapons introduced since the end of World War II. WW II represents, in many respects, an incubator, since manned jet aircraft, ballistic missiles, helicopters, and UAVs all made their combat debut during the war.

[94] The Predator vastly underperforms along traditionally valued dimensions. For example, rarely does the Predator's airspeed reach three digits. In contrast, manned fighters fly at supersonic speeds.

This study does not include cases of airpower-related innovations that occurred before WW II because the war represents a dividing line in the history of service behavior and organization. The primary locus of armed-service political activity shifted drastically as a result of the war; the complexity of modern war led to unification which linked the separate political universes of the services.[95] Furthermore, the experiences of WW II provided the political impetus for the creation, in 1947, of an independent U.S. Air Force, a service that holds great sway over whether and when new classes of airpower-related weapons are adopted.

In assessing whether the new, cross-disciplinary framework adds explanatory power, the case studies focus on four differences in the explanations offered by Barry Posen, Stephen Rosen, and Owen Coté and the model proposed in this study (see table below).[96]

	Key Relationship	Who Drives Innovation	Underlying Source of Innovation	Pace of Innovation
Posen	Civil-Military	Civilians	Changes in a State's Security Situation	Fast
Rosen	Intraservice	Mililitary	Changes in a State's Security Situation	Slow
Coté	Interservice	Civilians	Interservice Competition = Function (Civilian Management Sytle) 2	Fast or Slow
		Civilians and Military 4	Perceived Attributes 1	Commensurate With The Rate At Which Relative Advantage Evolves 3

First, do changes in a state's security situation and interservice competition, the two factors identified in doctrinal innovation literature as drivers of innovation, sufficiently explain when and why the U.S. military adopted the ICBM, the helicopter, and the UAV? Or, per this study's central hypothesis, did the perceived attributes of each also weigh heavily in leaders' decisions?

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[95] Samuel P. Huntington, "Interservice Competition and the Political Roles of the Armed Services," *The American Political Science Review,* Vol. 55, No. 1, March 1961, 40.
[96] This study does not dispute the key relationships that Posen, Rosen and Coté identify.

Second, is interservice competition, as Coté alleges, overwhelmingly a function of "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services"?[97] Or, did the perceived attributes of innovations also influence competitive and cooperative patterns of service behavior?[98] Third, is the pace of innovation binary? In other words, does it occur at one of two speeds: fast or slow? Or, does it tend to occur commensurate with the rate at which relative advantage evolves?[99] Fourth, did civilians *or* military leaders drive weapon system innovation, or were both civilians *and* uniformed leaders influential?[100]

Although the investigation compares the relative explanatory power of competing theories, it does not necessarily reject those that appear to least reliably describe the selected cases.[101] In that regard, the study follows an approach similar to Rosen and Coté's.[102] Posen concludes balance of power theory offers more explanatory power than organizational theory.[103] Nevertheless, he proclaims, "While the purpose of the theoretical exercise [was] to

[97] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 351. See also p. 339-340.
[98] Note: the model proposed in this study also asserts that the perceived attributes of innovations influence the nation's security situation (see Figure 2). The cases examined in Chapter 3-5, however, do not focus on that aspect of the model because it does not conflict with existing military innovation theory. Nevertheless, Chapter 3 provides an example. It discusses how the Soviet Union, our nation's Cold War enemy, perceived the ICBM to offer a greater relative advantage than the manned bomber. The perception influenced Soviet force-posture decisions, which, in turn, affected our nation's security.
[99] The idea accommodates a changing rate of weapon system innovation.
[100] Unlike Rosen, Posen, and Coté's theories, the model proposed in this study asserts civilian *and* military leaders can influence weapon system innovation. Moreover, it argues that leaders, whether civilians or military, are influenced by the three underlying factors that drive weapon system innovation: changes in a state's security situation, interservice competition, and the perceived attributes of innovations.
[101] Like Barry Posen's study, this dissertation examines "real outcomes to see which theory predicts more reliably" [Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 8].
[102] Stephen Rosen rejects the work of his predecessor, Barry Posen. Rosen declares, "In looking for an explanation, we are forced to go back to the beginning" [Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 18].
[103] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 239.

come to some conclusion about which theory is more powerful, it is clear that substantively the two theories provide complementary explanations of a complicated and important aspect of state behavior."[104] Later in his study, Posen remarks, "A more thorough understanding of [military innovation] can be achieved by employing the two theories in combination than by employing either separately."[105] Similarly, Coté concludes that his theory offers more explanatory power Posen and Rosen's but does not dismiss his predecessors' insights. He layers his theory on top of theirs, claiming that interservice competition can an act as a powerful intervening variable or act alone and independently.[106] Like Posen and Coté's studies, this investigation also takes an inclusive approach. The cross-disciplinary framework that it proposes integrates two explanatory factors culled from doctrinal innovation theory with one from diffusion of innovations (DOI) theory (see Figure 2).[107] While the three cases explored in Chapters 3-5 afford opportunities to assess the relative explanatory power of each factor, the test is not designed to disprove the validity of the seminal theories from which they were derived.

Assessing the relative explanatory power, however, requires a discussion that some readers may perceive as criticism of my predecessor's research. Far from it. Any perceived criticism should be considered in the same vein as Posen's critique of political science theory. Political scientists did not craft their theories to explain doctrinal innovation, and Posen offers his assessment as a way for political science theory to cast a wider explanatory net. Likewise,

[104] Ibid, 8-9.
[105] Ibid, 37.
[106] Coté declares, "I argue that when there is intense interservice conflict, doctrinal innovation can occur even in the face of strong civilian and intraservice opposition. Likewise, when the need to preserve interservice cooperation is strong, innovative doctrines can be suppressed even when they have strong civilian and intraservice support" [Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 13].
[107] Note: business innovation theory helps address a shortfall in DOI theory.

this dissertation recognizes that Posen, Rosen, and Coté do not necessarily claim their theories apply to weapon system innovation, and this investigation seeks to expand the applicability of doctrinal innovation theories rather than disparage their seminal studies.[108] Accordingly, this investigation is a testament to the strength of their intellectual frameworks. The dissertation remains indebted to Posen, Rosen, and Coté's insights, building on them to craft a new way of thinking about weapon system innovation.

CHAPTER OUTLINE

Chapter 2 explains why the U.S. armed services perennially pursue sustaining innovation. Next, it identifies factors that influence the adoption of disruptive innovation.

The cases that follow (Chapters 3-5) comprise the core of the study. All three chapters follow the same structure; they use a technique called process tracing to investigate each case.[109] Then, it compares the explanatory power of Posen, Rosen, and Coté's theories with that offered by the new, cross-disciplinary framework. Chapter 3 explores the U.S. Air Force's adoption of the ICBM. It explains how technological advances, such as the development of a thermonuclear bomb and improvements made in missile navigation, increased the disruptive weapon system's relative advantage, making its adoption much more attractive. Three key leaders—Trevor Gardner, General Bernard Schriever, and General Thomas White—recognized

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[108] See earlier discussion on applicability of doctrinal innovation theory to weapon system innovation.

[109] Process tracing is "a method of within-case analysis to evaluate causal processes" [Tulia G. Falleti, "Theory-Guided Process-Tracing" in *Comparative Politics: Something Old, Something New* (American Political Science Association Newsletter), available at http://www.polisci.upenn.edu/~falleti/Falleti-CP-APSANewsletter06-TGPT.pdf]. The method does not solely rely on the comparison of variations across variables in each case, but also "investigate[s] and explain[s] the decision process by which various initial conditions are translated into outcomes" [Ibid]. It attempts to "uncover what stimuli the actors attend to; the decision process that makes use of these stimuli to arrive at decisions; the actual behavior that then occurs; the effect of various institutional arrangements on attention, processing, and behavior; and the effect of other variables of interest on attention, processing, and behavior" [Ibid].

the technological inflection point. Together, they helped engineer a radical change in the nation's nuclear arsenal against stiff resistance from the "bomber mafia," the dominant subculture which persisted within the U.S. Air Force for more than thirty years after the service gained its independence from the U.S. Army in 1947 and viewed the ICBM as a threat to its preferred weapon.[110] Despite threatening the internal power structure of the U.S. Air Force, ICBMs were, in many ways, more compatible with it than the other services, which is one of the reasons why the Air Force adopted strategic nuclear missiles before the others.[111] General White put the ICBM at the top of the Air Force's research & development and acquisition priority lists in 1954, years before the other services acted.

Chapter 4 investigates the U.S. Army's adoption of the helicopter. The U.S. Air Force's pursuit of ever-more-perfected versions of its favored weapon, the strategic nuclear bomber, led to increasing discontent within the Army and ripe conditions for the adoption of helicopters. The Army, not served well by the Air Force's focus, felt that the flying service neglected its responsibilities to provide close air support and other missions augmenting ground operations.[112] "Since 1947, … the Army has been a dissatisfied customer, feeling that the Air Force has not fully discharged its obligations undertaken at the time of unification,"

[110] The term "bomber mafia" has owes its origins in the politics of ACTS. The ACTS was dominated by a close-knit group of officers who believed that long-range heavy bomber aircraft in large numbers would win any war and consequently the bomber should take a primary position in planning and funding. They argued that an enemy's army and navy could be defeated intact due to the destruction of industrial and military targets deep within enemy-held territory. For a more detailed discussion of the origins of the term, see Walter J. Boyne, "The Tactical School," *Air Force Magazine*, September 2003, 81-82, available at http://www.airforce-magazine.com/MagazineArchive/Documents/2003/September%202003/0903school.pdf.
[111] The U.S. Air Force, a service born from airpower technology, had an institutional interest in preserving its strategic nuclear monopoly. Moreover, its forte was thinking through how to use airpower strategically.
[112] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 165.

stated General Maxwell D. Taylor, U.S. Army chief of staff (1955-1959).[113] Prevented from rebuilding its own fixed-wing air force due to bureaucratic limitations, the Army invested in helicopters, a substitute, albeit an imperfect one, for fixed-wing aircraft.[114] Helicopters provided the Army with a "good enough" option for airpower, which, in many ways, was more compatible with ground operations than fixed-wing aircraft. The Army used the fact that helicopter technology blurred previously defined roles-and-missions boundaries to nibble away at geographic, weight, and functional restrictions that prevented it from acquiring its own airpower. The U.S. Army adopted the helicopter first for peripheral roles (e.g., medical evacuation, search and rescue, reconnaissance, etc.); over time, helicopters assumed core mobility and firepower functions.

Helicopters cut their teeth during the Korean War, an opportune trial-by-fire showcasing their promise, but one that also highlighted performance limitations of early rotary-wing aircraft. Korean War-era choppers could barely pick themselves off the ground on a warm day. A technological breakthrough, the development of the turbine engine in the latter half of the 1950s, vastly improved rotary-wing performance. Turbine-powered helicopters provided considerably more lifting power than piston-powered choppers, which greatly expanded the range of missions they could accomplish. The onset of the Vietnam War, another conflict in which helicopters were tried and tested in battle, served to accelerate their growth.

[113] Maxwell D. Taylor, *The Uncertain Trumpet* (Westport, CT: Greenwood Press, 1974), 168. See also Morton H. Halperin, Priscilla Clapp, and Arnold Kanter, *Bureaucratic Politics and Foreign Policy* (Washington, DC: Brookings Institute, 1974), 45.

[114] In addition to helicopter technology, the U.S. Army also explored tactical missiles and rocket batteries to make up for the loss of their organic airpower. Prevented from rebuilding an organic fixed-wing force, the alternative to developing a rotary-wing force for the Army would have been to remain dependent on the Air Force, not an attractive option.

Chapter 5 examines the rapid growth of unmanned aircraft within the U.S. Air Force and U.S. Army. For a variety of reasons, helicopters have not entirely satisfied the Army's airpower requirements.[115] Chapter 5 picks up the story with the B-2 Spirit, the swan song of the "bomber mafia" and the epitome of technological overshoot. Next, it describes how fighter pilots, after they displaced the bomber pilots to become the Air Force's dominant subculture, perpetuated a similar cycle of sustaining innovation leading to technological overshoot. Not surprisingly, when fighter pilots gained power, they advocated for more and better fighters, culminating most recently in the acquisition of a $361 million fighter, the F-22 Raptor.[116] The shift in the Air Force's focus from manned nuclear bombers to fighters, whose principal role is air-to-air combat, did little to alleviate the Army's discontent over the Air Force's support, and Army discontent is one of the factors that helped lead to the adoption of unmanned aircraft. Unmanned aircraft benefited from a confluence of several critical enabling technologies in the early 1990s, such as the Global Positioning System, advanced micro-processors, and wide-band satellite communication links, allowing drones to break free from their seemingly perpetual emergent state. Three key leaders—General Ron Fogleman, General John Jumper, and Defense Secretary Robert Gates—intervened, overcame institutional resistance, and helped push the Air Force to adopt unmanned aircraft.

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[115] Helicopters, for example, are extremely vulnerable. The U.S. Army lost nearly 5,000 helicopters in the Vietnam War, mostly to small arms and light machine guns. In the subsequent decades, technological developments made flying helicopters in combat somewhat safer, but sending slow, low-flying aircraft into hostile situations remains inherently dangerous, which the Army's experience in Iraq and Afghanistan has underscored ["Iraq: Crashes, Collisions Call into Question Vulnerability of Helicopters In Battle," 25 March 2003, http://www.defense-aerospace.com/article-view/feature/18891/iraq%3A-helicopter-vulnerability-questioned.html].

[116] The Government Accountability Office lists the Raptor's program unit cost as $361M [Government Accountability Office, "Defense Acquisitions: Assessments of Selected Major Weapon Programs" (GAO-06-391), March 2006, 67 available at htp://www.gao.gov/new.items/d06391.pdf]. The U.S. Air Force lists the jet's price tag as $143M, but that figure represents the "flyaway cost," what it would cost to acquire each additional aircraft if the production was not curtailed [U.S. Air Force, "F-22 Fact Sheet," available at http://www.af.mil/information/factsheets/factsheet.asp?id=199].

Lastly, Chapter 6 draws conclusions and speculates about the future of airpower. Although forecasting in the social sciences is more art than science, generalizations derived from this study should allow some rough predictions.[117] The chapter also highlights policy implication from the study's findings. It ends by suggesting future research.

STUDY FINDINGS

This study illustrates that weapon system innovation depends on the actions of those in power.[118] In all three cases investigated in this study, the adoption of disruptive innovation required the intervention of change agents, individuals who shepherded technological shifts despite facing powerful normative forces resistant to change.[119] Those serving in positions of power within the armed serves seemed to hold the reins of innovation, although civilians helped reinforce and accelerate the adoption of new classes of weapons. What drove these change agents to act? Historical evidence suggests that the perceived attributes of each

[117] Posen, Rosen, and Coté also use generalizations from their research to make predictions. For example, Posen states "Lessons derived from [my research] should be valid for many years to come, and should allow some rough predictions about the future" [Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 35]. Likewise, Rogers declares, "Generalizations about such attributes as relative advantage or computability to explain the rate of adoption are derived from *past* research, but these generalizations can be used to predict the rate of adoption of innovations in the future" [Everett M. Rogers, *Diffusion of Innovations*. 5th ed. (New York: Free Press, 2003), 227].

[118] Unlike commercial products, whose birth depends on the decision of a firm's management but whose takeoff and growth ultimately depend on market forces, the fate of a new weapon system hinges largely on governmental decisions. The Defense Department, in concert with the President and Congress, not only decides what gets developed, but also what gets adopted. Consequently the takeoff and growth of a new class of weapon cannot occur without those in positions of power breaking from the sustaining norm, changing what they demand, and adjusting resource-allocation priorities to shepherd a technological shift.

[119] "Change agents" refers to individuals who, as the name of the term implies, serve as catalysts for change. For a brief summary of the literature relating to the term "change agent," see Oswald Jones, "Kicking Against the Pricks: Corporate Entrepreneurship in Mature Organizations" in *Technological Change and Organizational Action*, Eds. David Preece and Juha Laurila (New York, NY: Routledge, 2003), 122-123. Note: business innovation literature sometimes substitutes "product champion," a synonym for "change agent" [Alok I. Chakrabarti, "The Role of Champion in Product Innovation," *California Management Review*, Vol. XVII, No. 2, Winter 1974, 59, available at http://web.njit.edu/~chakraba/champion-cmr.pdf]. Use of the term "change agent" is also prevalent in DOI literature [see Everett M. Rogers, *Diffusion of Innovations*. 5th ed. (New York: Free Press, 2003), 373].

innovation, especially relative advantage, weighed heavily in their decisions. Interservice competition and changes in the nation's external security situation also helped drive the actions of change agents, although to a lesser degree.

What do these findings portend for the future of unmanned aircraft? It appears highly likely that exponential growth in UAV operations will continue. "It's a growth market," observes Deputy Secretary of Defense Ashton Carter, who previously served as the Pentagon's chief weapons buyer.[120] The Defense Department remains committed to purchasing approximately 730 new medium and large-sized unmanned aircraft over the next 10 years, while upgrading its fleet of UAVs already in service and investing in research and development that will deliver the next generation of more technologically advanced systems.[121] These new generations of UAVs will likely continue to erode the relative advantage offered by manned aviation, providing improved reconnaissance and attack capabilities as well as broadening the missions that UAVs perform. As a result, unmanned aircraft are poised to assume an ever-larger role in air warfare as they graduate from peripheral to core roles. In sharp contrast, manned fighters and bombers have, for decades, suffered declining numbers. Tellingly, not a single Western aerospace company has a new manned fighter in research and development.[122]

Even with large cuts looming over defense spending in the coming decade, President Barack Obama and Secretary of Defense Leon Panetta announced their intention not only to protect unmanned aircraft from funding reductions, but to substantially increase investment in

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[120] "Drones Transform How America Fights Its Wars," *New York Times*, 20 June 2011, available at http://www.nytimes.com/slideshow/2011/06/20/world/20110620-DRONES-7.html.

[121] Congressional Budget Office, "Policy Options for Unmanned Aircraft Systems," June 2011, ix, available at http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/121xx/doc12163/06-08-uas.pdf.

[122] "War By Remote Control: Drones Make It Easy," National Public Radio, 26 November 2011, available at http://www.npr.org/2011/11/26/142781012/war-by-remote-control-drones-make-it-easy.

UAVs as part of a new defense strategy that shifts emphasis from today's wars to preparing to overcome emerging security challenges.[123] As part of the newly announced strategy, the U.S. Air Force, which already trains more remote pilots than it does fighter and bomber pilots combined, anticipates quadrupling the number of its multirole drones over the next decade while continuing to cut its manned fleet.[124] Similarly, the U.S. Army envisions transitioning to a predominantly unmanned aviation force over the next twenty-five years, with manned aircraft retaining the lead role in only two missions, medical evacuation and utility.[125] U.S. Army plans include the rapid expansion of its unmanned aviation force, to include rebuilding a high-tech, fixed-wing air force, something it has not had since the U.S. Army Air Force broke away from the service to form an independent Air Force seven decades ago. The Army's unmanned expansion sets the stage for increasingly intense interservice competition, a factor likely to fuel willingness to cannibalize and accelerate a transition from manned to unmanned aircraft.[126]

No one, however, has a crystal ball, and the outcome of the apparent unmanned revolution in airpower is not a foregone conclusion. Ultimately, the future mix of unmanned and manned aircraft in the nation's inventory rests on continued willingness to cannibalize.

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[123] Leon Panetta, "Statement on Defense Strategic Guidance" (speech, Pentagon, Washington, DC), 5 January 2012, available at http://www.defense.gov/speeches/speech.aspx?speechid=1643.
[124] Elisabeth Bumiller and Thom Shanker, "War Evolves with Drones, Some Tiny as Bugs," *New York Times*, 19 June 2011, available at http://www.nytimes.com/2011/06/20/world/20drones.html?pagewanted=all.
[125] *U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035*, June 2010, 60, available at http://www.fas.org/irp/program/collect/uas-army.pdf.
[126] Sandra I. Erwin, "Army on a Fast Track to Build its Own High-Tech Air Force," *National Defense*, April 2010, available at http://www.nationaldefensemagazine.org/archive/2010/April/Pages/Armytobuilditsownairforce.aspx. Although the Navy lags well behind the Air Force and Army in the development and development of armed drones, it plans to plans to conduct sea trials with a prototype in 2013 and to deploy the system on carriers in 2018 [Thomas P. Ehrhard and Robert O. Work, "Range, Persistence, Stealth, and Networking: The Case for a Carrier-Based Unmanned Combat Air System," Center for Strategic and Budgetary Assessments report, 2008, 5, available at http://www.csbaonline.org/wp-content/uploads/2011/02/2008.06.18-The-Case-for-Carrier-Based-Unmanned-Combat-Air-System.pdf. See also Graham Warwick, "Unmanned Combat Aircraft Tests Move Quickly," *Aviation Week*, 6 December 2011, available at http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=awst&id=news/awst/2011/12/05/AW_12_05_2011_p54-398723.xml].

Resistance to unmanned aircraft may stiffen, particularly in the U.S. Air Force, as unmanned aircraft continue to progressively threaten and displace manned aircraft in core roles. As a result, uniformed leaders may decide to remain wedded to manned aviation, effectively conjoining their service's future to the life cycle of existing weapon systems. Or, they may perceive that perpetuating cycles of sustaining innovation and acquiring ever-more-perfected versions of manned aircraft like the Joint Strike Fighter, a plane that if procured will become the most expensive weapon system in history, do not represent the best strategic choices for their service or the nation.[127]

Perhaps the track record and operational difficulties of the F-22 Raptor, the latest fifth-generation manned fighter to enter the ranks of the U.S. Air Force, an airplane former Secretary of Defense Robert Gates called a "niche, silver-bullet solution required for a limited number of scenarios," foretells the future.[128] Despite the first production model taking flight in September 1997, the advanced fighter has yet to fly a single combat sortie. Ironically, flaws in the plane's oxygen system, vital for sustaining life in an airborne cockpit, led the U.S. Air Force to ground the plane for over four months in 2011. In contrast, the Predator, which took to the skies at about the same time as the Raptor, became a combat workhorse in Iraq and Afghanistan. The Predator's success, despite the technology's immaturity, gives the impression that the tables have already turned, with unmanned aircraft fulfilling core missions while manned aircraft are increasingly being relegated to niche roles. Indeed, the media's use of the term "drone war" to

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[127] Lee Ferran, "F-35 Fighter: Price Goes Up $771 Million on Most Expensive Defense Program," *ABC News*, 14 July 2011, available at http://abcnews.go.com/Blotter/lockheed-martin-35-fighters-cost-771/story?id=14071402.
[128] Rebecca Grant, "The Evolution of Airpower Under Gates," *Air Force Magazine*, February 2011, 57.

describe air operations in Pakistan and elsewhere suggests General “Hap” Arnold’s vision of pilotless aircraft fighting our nation’s wars has arrived.[129]

[129] For example, see “U.S. Drone War Returns to Pakistan (And It Ain’t Stopping),” *Danger Room*, 11 January 2012, available at http://www.wired.com/dangerroom/2012/01/drone-war-return/.

CHAPTER 2

SUSTAINING, VERSUS DISRUPTIVE, INNOVATION

"Firms must break out of the natural human trait that propels them to use yesterday's bag of tools to solve tomorrow's problems. They must do so today, while they still have options, not tomorrow, when they have nothing left but a useless bag of tools. They must be willing to cannibalize before there is nothing of value left to cannibalize."[130]

— *Gerard Tellis and Rajesh Chandy*

As outlined in Chapter 1, this dissertation proposes a new, cross-disciplinary framework to describe airpower-related weapon system innovation. It contends three factors, grouped under a concept called "willingness to cannibalize," underlie and influence weapon system innovation: interservice competition, changes in a state's security situation, and the perceived attributes of innovations.[131] The first two factors come from doctrinal innovation literature, while the third arises from diffusion of innovations (DOI) research. The study hypothesizes, based on a central finding of DOI research, that four perceived attributes—relative advantage, compatibility, trialability, and observability—of which relative advantage is the most important, accounts for the majority of the variance in whether and how quickly new weapons are adopted.[132] This chapter expounds on that hypothesis. First, it explains why the U.S. armed services perennially pursue sustaining innovations. Next, it explains why, despite the norm of sustaining innovations, they occasionally adopt disruptive innovations.

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[130] Rajesh K. Chandy and Gerard J. Tellis, "Organizing for Radical Product Innovation: The Overlooked Role of Willingness to Cannibalize," *Journal of Marketing Research* Vol. XXXV, November 1988, 485.
[131] See Figure 2, Chapter 1.
[132] Everett M. Rogers, *Diffusion of Innovations*. 5th ed. (New York: Free Press, 2003), 221.

PERENNIAL SUSTAINING INNOVATON

Although interservice competition and changes in a state's security play a role in the adoption of disruptive innovation, a better explanation for why the services perennially pursue sustaining innovations lies in the perceived attributes of sustaining innovations as compared with those of disruptive innovations. Simply stated, the services perennially pursue sustaining innovations because they characteristically offer greater relative advantages than disruptive innovations. Disruptive innovations tend to have higher uncertainty surrounding any payoff, lower perceived benefits (at least from an incumbent's perspective), and higher organizational costs, which translates, all else being equal, into lower expected values versus sustaining alternatives.

Adopting disruptive innovations require a military service to contemplate self-induced organizational pain with only the possibility of an uncertain payoff.[133] Switching from existing to new classes of weapons may offer potential benefits, but they accrue at a future and unknown time, if they happen at all.[134] "Confidence in a weapon system comes from precedent, and by definition, [new classes of weapons] lack precedent," observes Thomas Ehrhard.[135] "Fully integrated, or legacy weapon systems possess deficiencies, of course, but those deficiencies are known and are figured into training and operations."[136] Ehrhard

[133] Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 8.
[134] Everett M. Rogers, *Diffusion of Innovations*. 5th ed. (New York: Free Press, 2003), 233.
[135] Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 8.
[136] Ibid.

continues, "Military organizations abhor self-inflicted chaos because war is already rife with it. Known quantities install confidence, unknowns illicit fear."[137]

Not only does the potential payoff from adopting disruptive innovations involve greater uncertainty, but from an incumbent's perspective, adopting disruptive innovations tends to offer few benefits, if any, because they typically underperform, at least initially, existing weapons in the accomplishment of missions that an incumbent cares most about. For example, the reliability and accuracy of early Intercontinental Ballistic Missiles (ICBMs), which had less than a coin's flip chance of landing anywhere near a large city, could not match that offered by manned bombers, a weapon system that twice proved during World War II that it could reliably and accurately deliver nuclear payloads. Furthermore, adopting new classes of weapons commonly offer no greater payoff for an incumbent than maintaining its current "market position" (i.e., preserving its position relative to the other services). For example, the U.S. Air Force, with its fleet of manned bombers, enjoyed a monopoly on the strategic nuclear delivery mission for nearly two decades after WWII. Adopting ICBMs offered the U.S. Air Force the prospect of preserving that monopoly, but only if the other services did not follow suit.

Disruptive innovation, by definition, also incurs higher organizational costs than sustaining innovation.[138] Whereas sustaining innovations improve the performance of established weapon systems and build upon existing assets (i.e., they build upon an organization's existing skills, competencies, routines, knowledge, equipment, and support infrastructure), disruptive innovation can cause existing assets to lose relevance and value. For

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[137] Ibid.

[138] Compatibility also affects costs associated with adopting an innovation; incompatible systems increase costs, which drive down expected value.

example, pilots' stick-and-rudder skills become unnecessary and obsolete with the introduction of automated, unmanned platforms. Displacing an existing core weapon system with a new class of weapon requires the armed services to destroy or thoroughly redirect an important part of themselves, which can be quite contentious because subcultures within the armed forces largely derive their identities from the weapon systems they operate.[139]

Indeed, the armed forces and communities within them organize and define themselves based on the weapons they employ. The U.S. Air Force, an institution dominated by pilots since its inception in 1947, literally owes its independence as a service to a single technology—fixed-wing, manned aircraft. Consequently, it is no surprise that the manned airplane is the service's preeminent and defining platform. Community identities within the Air Force are platform-specific; aviator identity is divided according to different types of aircraft.[140] For example, the "bomber mafia," the dominant community within the Air Force for more than thirty years after it became a separate service, is defined by and owes its power to the manned bomber. Fighter pilots, another community defined by the type of aircraft flown, wrested institutional leadership from the "bomber mafia" after the adoption of intercontinental ballistic missiles reduced the importance and number of bombers in the Air Force's inventory, thereby weakening bomber pilot's grip on power.[141] Similarly, group identities within the U.S. Army and the U.S. Navy are also platform-specific. Identities within the Army revolve around combat

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[139] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 8.
[140] Carl Builder, *The Masks of War: American Military Styles in Strategy and* Analysis (Baltimore, MD: Johns Hopkins University Press, 1989), 22-24.
[141] "Fighter pilots started to dominate Air Force leadership when fighters came to dominate the force structure" [Rebecca Grant, "In Defense of Fighters," *Air Force Magazine*, July 2002, available at http://www.airforce-magazine.com/MagazineArchive/Pages/2002/July%202002/0702fighter.aspx. See also Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership: 1945-1982* (Maxwell Air Force Base, AL: Air University Press, 1998), 124.

branches, which are predominately defined based on the type of weapon system each branch employs as its main tool in battle. In fact, many of the Army's combat branches are even named after specific equipment (e.g., Armor, Field Artillery, and Air Defense Artillery, among others). Likewise, the Navy organizes its combat branches around three categories of weapons—surface ships, submarines, and aircraft, which can be further subdivided based on type. Community identities within the Navy closely follow those technological divisions.[142]

The intensity of the armed services' commitment to existing weapons is made acute by a seniority promotion system that requires officers to spend decades working their way up the ranks of a single service. The armed services are manned by careerists on a structured ladder; promotion to higher ranks depends on years of demonstrated, distinguished devotion to a single service's mission.[143] Lateral transfers from one military service to another are not permitted, nor are civilian executives from other public or private institutions appointed to leadership positions within the military. As a result, senior military leaders naturally develop a strong affinity for their service's existing weapons because they have invested so much time and effort in their success. By the time officers are eligible for promotion to flag rank, they have spent the majority of their adult lives manning and managing those systems. Furthermore, on a professional level, senior military leaders are also the ones who have benefited the most from the current system and thus, have a collective vested interest in preserving it.

[142] The U.S. Marine Corps is perhaps the least inclined of all the services to define itself by technology. Nevertheless, the Marine Corps' leadership, which is dominated by the infantry subgroup, remains intensely committed to specialized investments that deliver combat support to the Marine rifleman in the performance of the amphibious-assault mission or combined operations from the sea. See *Marine Corps Vision & Strategy 2025*, available at http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA519807.

[143] Graham Allison and Phillip Zelikow, *Essence of Decision*, 2nd ed. (New York: Addison-Wesley Educational Publishers, 1999), 168.

The identities of the armed services and the communities within them are so strongly connected to their weapons that existing classes of weapons become synonymous with preferred doctrine.[144] Accordingly, it is no coincidence that manned fighters, the main battle tank, and aircraft carriers are of central importance institutionally for the U.S. armed forces and their respective components and hence, the renewal of those weapons in ever-more-perfected versions greatly preoccupies service organizations, their military chiefs, and their civilian appendages.[145] Each service's force-posture strategy is a carefully woven fabric of sub-strategies that more clearly supports institutional interests in rationalizing the existing force mix than it does the U.S. national strategy or security interests.[146] The result: canonical weapons platforms that came of age during World War II have endured despite all the new possibilities opened by technological advancements in the past six decades.[147]

In summary, disruptive innovations tend to have higher uncertainty surrounding their payoff, lower perceived benefits (at least from an incumbent's perspective), and higher organizational costs, which puts them at a relative disadvantage versus sustaining alternatives.

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[144] As noted in Chapter 1, both Barry Posen and Owen Coté rely on this relationship in their research. Posen states, "Force posture, the inventory of weapons any military organization controls, can be used as evidence to discover military doctrine" [Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 14]. Owen Coté agrees with and quotes Posen verbatim [Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 6].

[145] Edward N. Luttwak, "Breaking The Bank: Why Weapons Are So Expensive," *American Interest,* September-October 2007, http://www.the-american-interest.com/article.cfm?piece=323. Existing weapon systems designed to meet present and near-term threats command more acquisition and planning attention than weapons systems designed to meet uncertain future threats. Moreover, as Luttwak notes, military culture is imbued with strong romanticisms for past victories, legends, and folklore, which affects the way activities are accomplished and the types of weapons senior leaders prefer. He accuses them of being "prisoners of tradition" [Ibid].

[146] Gerald E. Marsh, "Serving and Protecting Themselves," review of Carl H. Builder, *The Masks Of War: American Military Styles In Strategy And Analysis* (Washington, DC: Johns Hopkins University Press, 1989).

[147] Edward N. Luttwak, "Breaking The Bank: Why Weapons Are So Expensive," *American Interest,* September-October 2007, http://www.the-american-interest.com/article.cfm?piece=323.

As a result, sustaining innovations remain the norm. Nevertheless, the armed services do, on occasion, adopt new classes of weapons.

DISRUPTIVE INNOVATON, THE EXCEPTION

Enticing leaders to adopt new classes of weapons requires disruptive innovations to somehow overcome their characteristic relative disadvantage.[148] In explaining when and why that occurs, this study acknowledges that interservice competition and changes in a state's security situation, the two factors doctrinal innovation literature identifies as influential, can sway decision makers. However, it maintains, per a central finding of DOI research, that the perceived attributes of innovations also weigh heavily in decisions to adopt disruptive innovations.[149] Accordingly, this section describes how relative advantage can evolve to favor new classes of weapons over existing ones.

Unfortunately, DOI research fails to provide any insight on how that happens. Worse, explaining when and why shifts in relative advantages may occur is not necessarily intuitive. Given how the U.S. military invests the vast majority of its research and development (R&D)

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148 In a certain respect, Everett Rogers's diffusion of innovations (DOI) theory and Christiansen disruptive innovation theory are in tension. The former explains why the armed services perennially pursue sustaining innovations, while the latter helps explain how that can change.

149 To emphasize, the perceived attributes of innovations form the heart of this study's cross-disciplinary model. Not only do they directly influence key decision makers' "willingness to cannibalize," but they also exert indirect influence through the other two underlying sources of weapon system innovation: changes a state's security situation and interservice competition (reference the arrows emanating from the "perceived attributes" box in Figure 2, Chapter 1). The reason why they exert indirect influence is straightforward; the perceived attributes of existing and new weapons influence the force-posture decisions of allies and adversaries as well as those of all the services, which, in turn, influence the nation's strategic situation and whether interservice competition emerges. The latter assertion, that the perceived attributes of innovations influence interservice competition, is especially noteworthy since Owen Coté alleges "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services" is the overriding determinant of competitive and cooperative patterns of service behavior [Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 351]. This study suggests that the perceived attributes of innovations also play a role in whether interservice competition emerges.

towards delivering sustaining rather than disruptive innovations, one would expect existing weapons to retain, or perhaps even add to, their relative advantage over disruptive weapons. For example, in fiscal year (FY) 2013, the Defense Department plans to spend nearly seven times more on R&D for manned than unmanned aircraft.[150] If procurement spending is also included in the comparison, the budget for manned aircraft exceeds that of unmanned aircraft more than thirteen times.[151] The spending inequity between manned and unmanned aircraft is all the more remarkable considering how funding for unmanned aircraft has grown exponentially over the last decade. Fortunately, Clayton Christensen, a business innovation scholar, points to a partial answer. Christensen identifies two patterns in commercial innovation, which this study contends are also exhibited in weapon system innovation. The first pattern helps explain how cycles of sustaining innovation paradoxically diminish the relative advantage offered by each generation, and the second identifies a common path of adoption for disruptive innovations.

Christensen observes that incumbent commercial firms habitually pursue sustaining innovations. Likewise, as explained in the previous section, the armed services perennially pursue sustaining innovations. Albeit for different reasons, cycles of sustaining innovation, whether in a commercial or military context, similarly lead to ripe conditions for the adoption of disruptive innovation.[152] In a military context, perennial sustaining innovation makes existing

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[150] Derived from "DoD Aircraft Programs and Expenses," a table available at http://www.bga-aeroweb.com/DoD-Aircraft-Programs.html [Original source: http://comptroller.defense.gov/budget.html]. Note: unmanned aircraft are nowhere to be found among the Pentagon's top 25 most expensive programs, a list which contains 11 manned aircraft [Peter W. Singer, "U-Turn," *Armed Forces Journal*, April 2011, available at http://www.armedforcesjournal.com/2011/04/5787503].

[151] Ibid. The funding inequity between manned and unmanned aircraft grows is one also considers operations and maintenance (O&M) spending.

[152] Christensen's research suggests the incumbent commercial firms, capture to their best customers, deliver improvements in existing products that exceed what mainstream customers demand or can absorb [Clayton M.

weapons more capable, but it also tends to produce ever-more complex and costly weapons, making them less cost efficient. Furthermore, because more costly weapons are less affordable, perennial sustaining innovations typically lead to fewer systems being acquired with each generation, which naturally erodes the ranks and status of the subculture that derives its identity and power from that weapon system. This occurs for a very straightforward reason—a reduction in the quantity of a particular weapon system translates into a smaller officer constituency and, all else being equal, that leads to waning influence.

Historical evidence suggests sustaining innovation leading to ever-more complex and costly manned aircraft is endemic among the U.S. armed forces. Norman Augustine, an aerospace executive who became the chairman of the board of directors of Martin Marietta Corporation, was perhaps the first to point out, in 1983, that unit costs of manned fighter and bomber aircraft had grown exponentially since the Wright Brothers first flew their Model A. [153] Augustine also noticed that unit cost increases in manned fighters and bombers far exceeded the rate of growth in defense spending, which led him to famously make the following tongue-in-cheek prediction: "In the year 2054, the entire defense budget will purchase just one tactical

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Christensen, *Innovator's Dilemma*, First Collins Business Essentials ed. (New York, NY: HarperCollins, 2006), xxvii].

[153] Norman R. Augustine, *Augustine's Laws*, 6th ed. (New York, NY: Viking Penguin, 1986), 109. Note: exponentially increasing costs are not unique to fighter aircraft; the Government Accountability Office reports that the total acquisition cost for the current portfolio of all major weapon programs under development or in production in the United States has grown by nearly $300 billion over initial estimates, up from $42 billion when a similar study was conducted seven years earlier [General Accounting Office, "Defense Acquisitions: Assessments of Selected Weapon Programs," Report to Congressional Committees (GAO-08-467SP), March 2008, 7]. Deloitte, a top accounting firm, calculates cost overruns are increasing by an average rate of 1.86 percentage points per year and are poised to get worse in the foreseeable future [Sandra I. Erwin, "Weapon Cost Overruns: From Bad to Worse," *National Defense*, January 2009, available at http://www.nationaldefensemagazine.org/archive/2009/January]. "At the current pace, unless game-changing mitigations are implemented to address the root causes, the analysis forecasts that in 10 years the average cost overrun may exceed 46 percent, up from 26 percent today" [Deloitte Consulting, "Can we afford our own future? Why A&D programs are late and over-budget — and what can be done to fix the problem," 2009, 1, http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/US_AD_CanWeAffordOurOwnFuture_0127.pdf].

aircraft. This aircraft will have to be shared by the Air Force and Navy, three and one-half days per week, except for the leap year, when it will be made available to the Marines for the extra day."[154] Thirty years later, Augustine's astute observation about the rising cost of aircraft, to use a pun, remains on the money. Figures 4 and 5, respectively, document the exponential cost-growth of fighters and bombers since the early days of manned aviation.[155] Note: the y-axes in Figures 4 and 5 are measured on a log scale, which means that the upward sloping trend lines show exponentially increasing costs. Augustine's tongue-in-cheek prediction for declining numbers has also proved prophetic. Figures 6 and 7, respectively, graph the lifecycle curves for manned jet bombers and fighters in the U.S. Air Force's inventory and document a significant decline in numbers for each.

[154] Norman R. Augustine, *Augustine's Laws*, 6th ed. (New York, NY: Viking Penguin, 1986), 143.

[155] Although the focus of this study is on airpower-related innovation, it is interesting to note that a similar pattern is also evident when examining the cost of new ships. A Rand report found nearly identical average annual price increases for new fixed-wing aircraft and new ships, both of which have experienced cost increases at nearly double the rate of inflation. The report divided aircraft into various categories—patrol, cargo, trainer, bomber, attack, fighter, and electronic warfare—and found that the rate of inflation for aircraft ranged from 7 to 12 percent annually. Likewise, for every type of ship the report examined—amphibious ships, surface combatants, attack submarines, and aircraft carriers—inflation ranged from 7 to 11 percent annually [Mark V. Arena, et al., *Why has the Cost of Fixed-Wing Aircraft Risen? A Macroscopic Examination of the Trends in U.S. Military Aircraft Costs over the Past Several Decades* (Santa Monica, CA: RAND, 2008), 11]. "The persistent price growth above the rate of inflation stems from the desire for greater capabilities," concludes Rand. "The navy has desired ever-more-complex ships: larger, faster, stealthier, more powerful … Likewise, the services have desired ever-more-complex aircraft" [Rand Corporation, "Cost Controls: How Government Can Get More Bang for Its Buck," *Rand Review*, Spring 2009, http://www.rc.rand.org/publications/randreview/issues/spring2009/cost3.html].

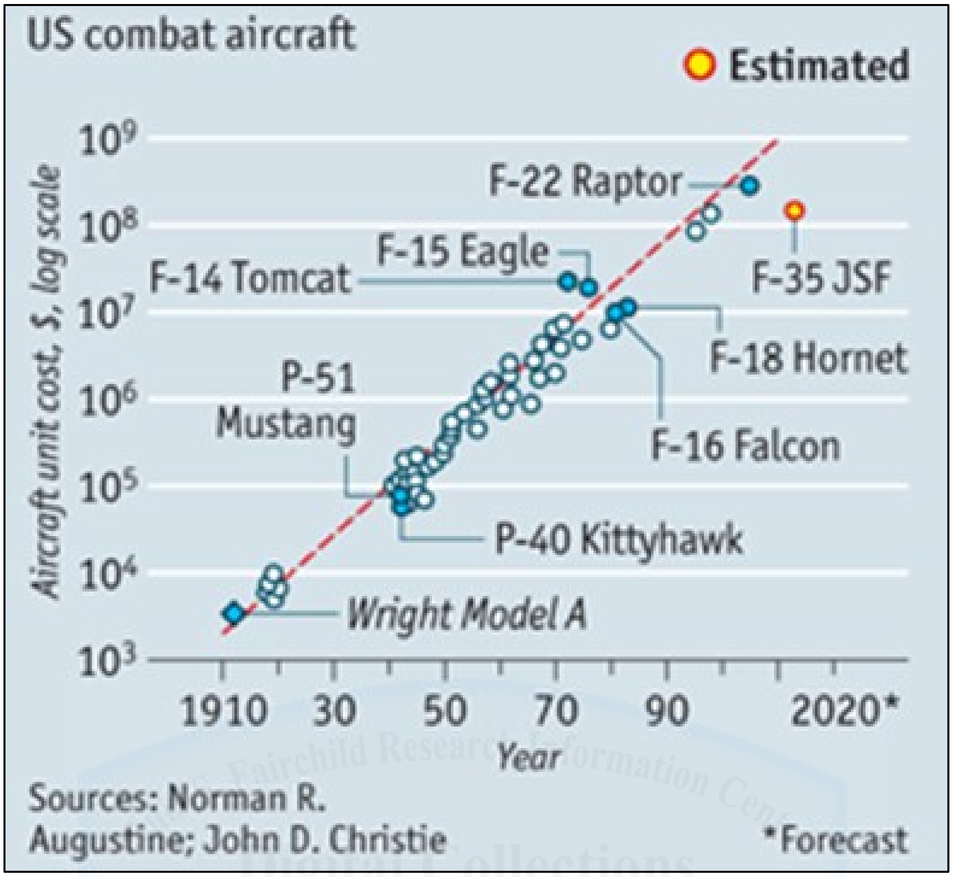

FIGURE 4 – A Consistent Pattern of Exponentially Escalating Unit Costs of Tactical Aircraft since the Wright Model A[156]

[156] "Defence spending in a time of austerity: The chronic problem of exorbitantly expensive weapons is becoming acute," *Economist*, 28 August 2010, 22, http://www.economist.com/node/16886851. Note: the United States Army Air Corps called the P-40 the "Warhawk." British and Soviet air forces also flew the P-40. They used the name "Tomahawk" for models equivalent to the P-40B and P-40C and the name "Kittyhawk" for models equivalent to the P-40D and all later variants [http://www.fighter-planes.com/info/p40_warhawk.htm].

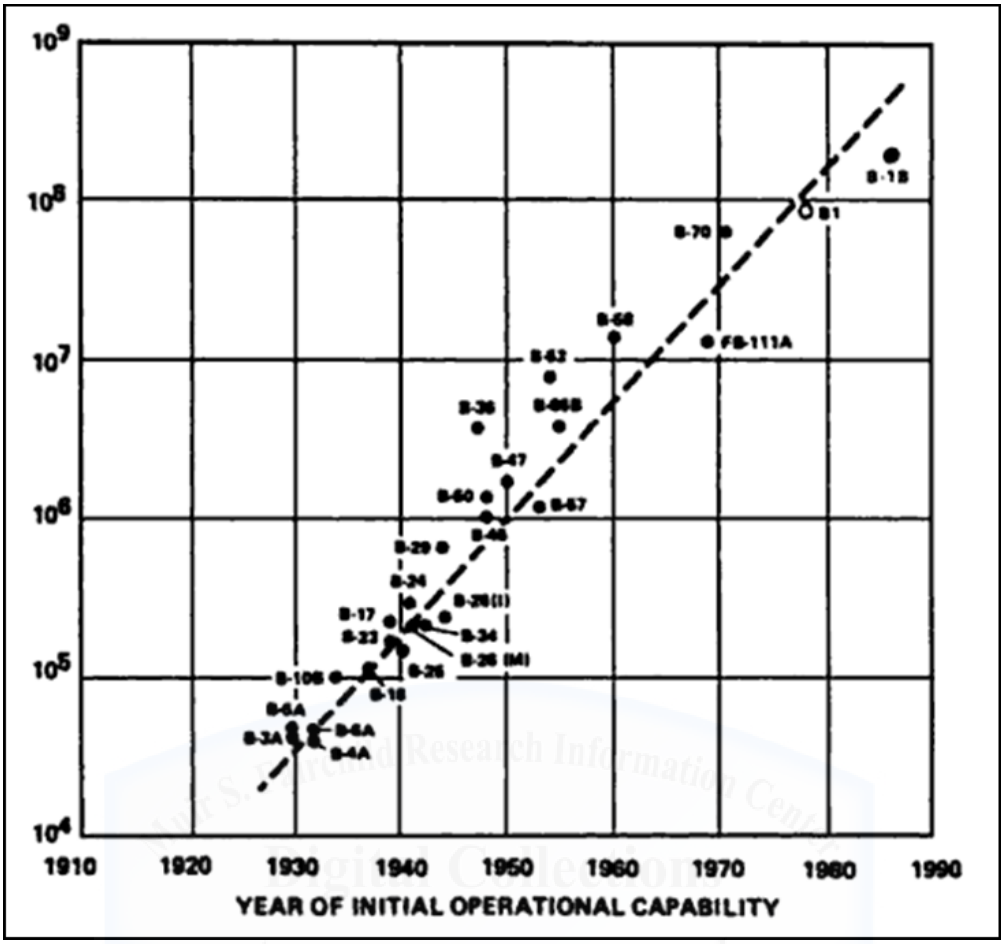

FIGURE 5 – A Consistent Pattern of Exponentially Escalating Unit Costs of Bomber Aircraft Since 1930[157]

[157] Norman R. Augustine, *Augustine's Laws*, 6th ed. (New York, NY: Viking Penguin, 1986), 109. Note: the chart does not include the B-2, the latest bomber to enter the U.S. military inventory. The B-2 continues the trend for exponentially rising unit costs. Note: Augustine also provides insightful statistics on the increasing complexity of bombers. He notes, "The World War II B-29 contained about 10,000 electronic component parts, the B-47 approximately 20,000, the B-52 50,000, and the B-58 nearly 100,000—or a factor of two for each generation. But this rate of growth has been eclipsed by the B-1, which is packed with microcircuits containing as many active elements on a single quarter-inch chip as were carried in an entire B-58 a few years earlier" [Ibid].

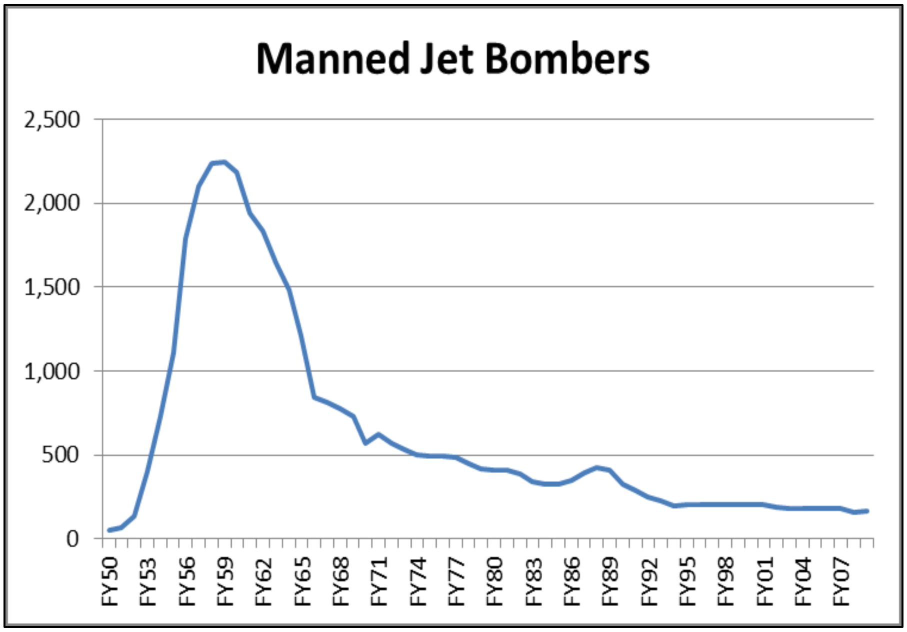

FIGURE 6 – The Manned, Jet Bomber Life-Cycle Curve[158]

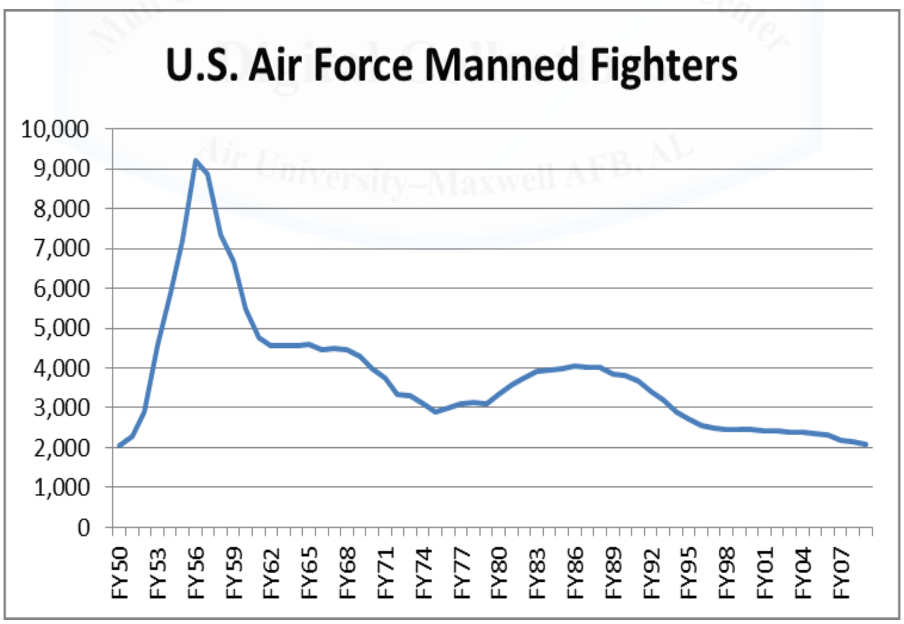

FIGURE 7 –The Manned, Jet Fighter Life-Cycle Curve (U.S. Air Force Inventory)[159]

[158] Source: James C. Ruehrmund, Jr. and Christopher J. Bowie, *Arsenal of Airpower: USAF Aircraft Inventory 1950-2009* (Arlington, VA: Mitchell Institute Press, 2010). Note: The adoption of the ICBM helped accelerate the decline in bomber numbers.

Cost and complexity feed off each other in a vicious, reinforcing cycle. The services demand ever-more-complex weapons packed with more and more features. This translates into more costly weapons because, as another one of Augustine's laws points out, the "last 10% of performance generates one-third of the cost and two-thirds of the problems."[160] More costly weapons mean the services can afford fewer of them. Instead of benefiting from economies of scale, the opposite occurs as planned production numbers are cut. This further inflates unit costs and makes new generations even less affordable. This causes the services to demand even more capability and more complex systems because the fewer systems that *are* acquired need to deliver even greater performance to make up for the decrease in quantity.[161] Furthermore, more complex weapons require longer acquisition timelines. Because technology does not remain static, this leads defense companies to more design changes midstream because parts or subsystems become obsolete during long acquisition timelines.[162]

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[159] Source: James C. Ruehrmund, Jr. and Christopher J. Bowie, *Arsenal of Airpower: USAF Aircraft Inventory 1950-2009* (Arlington, VA: Mitchell Institute Press, 2010). Note: Figure 7 shows a bulge in fighter numbers in the early 1980s that temporarily bucked the declining trend. This bulge can be attributed to two factors: first, President Reagan, during his two terms in office (1981-1988), increased defense outlays 213% [*U.S. Air Force Statistical Digest: Fiscal Year 1991*, 9, available at http://www.afhso.af.mil/shared/media/document/AFD-110419-007.pdf]. As part of that increase in defense spending, Reagan more than doubled the Air Force's budget, which enabled the service to purchase more aircraft, despite rising unit costs [Ibid, 13]. Second, Reagan's tenure coincided with a change in leadership within the Air Force. Savaged by declining numbers, bomber pilots managed to hold onto institutional power until July 1982, when General Charles Gabriel became the first fighter pilot to become chief of staff. Previous to Gabriel's selection as chief, an unbroken string of ten bomber pilots filled the Air Force's top leadership position. By 1982, jet bomber numbers had dropped to a level not seen since the early 1950s. Predictably, fighter pilots, once they came to power, developed and lobbied for more fighters. By 1985, the new dominant subculture had scored close to a fifty percent increase in the active-duty fighter inventory from a post-Vietnam low of 2,299 aircraft to more than 3,000 [Mike Worden, "Changing of the Guard," *Air Force Magazine*, July 2006, 60, available at http://www.airforce-magazine.com/MagazineArchive/Pages/2006/July%202006/0706guard.aspx]. The reprieve from declining numbers, however, was short-lived; the number of fighters has subsequently dipped below 2,000.

[160] Defence Spending in a Time of Austerity: The Chronic Problem of Exorbitantly Expensive Weapons is Becoming Acute," *Economist*, 28 August 2010, 22, http://www.economist.com/node/16886851.

[161] Edward N. Luttwak, "Breaking The Bank: Why Weapons Are So Expensive," *American Interest,* September-October 2007, http://www.the-american-interest.com/article.cfm?piece=323.

[162] For example, the F-22 Raptor took so long to produce that many of its parts suffered obsolescence before the first aircraft rolled off the assembly line ["Obsolete Parts Plague F-22 Before First Flight," *Janes Defence Weekly*, 13 August 1997, available at http://articles.janes.com/articles/Janes-Defence-Weekly-97/OBSOLETE-PARTS-

Additionally, the services also demand design changes midstream to incorporate the latest and greatest technological advances.[163] "With the increased inter-connectivity of designs, a change to one part often affects other parts in unpredictable ways – creating a ripple effect that can have serious consequences for the overall cost and schedule," concludes a report examining factors that make weapon systems less affordable.[164]

The U.S. military's experience developing the Joint Strike Fighter is illustrative. Paul Kaminski, Chairman of the Defense Science Board and former undersecretary for defense for acquisition and technology, frets:

> Sheer complexity is one of the things leading to the problems that we are having on the F-35. There are so many moving parts, so many different requirements and customers. When we look at the STOVL (short-takeoff-and-vertical-landing) version, you have a much tougher engineering trade-off, because if you end up short on bring-back capability, what you find is that adding means to improve that ends up adding weight. You're in a vicious cycle.[165]

PLAGUE-F-22-BEFORE-FIRST-FLIGHT.html]. The F-15's APG-63 radar modification provides another example of parts becoming obsolete before the first unit rolling off the production line. The contract was awarded in FY97 and finally installed in FY09. In the 11 years from when the contract was awarded to final installation, parts of the F-15's new radar went obsolete [Committee on Aging Avionics in Military Aircraft, Air Force Science and Technology Board, National Research Council, *Aging Avionics in Military Aircraft* (Washington, DC: National Academy Press, 2001), 29].

[163] Jan Muczyk, the former dean of the Air Force Institute of Technology's Graduate School of Logistics and Acquisition Management, blames "flag officers [who] want their weapon systems to do everything [and demand] changes throughout the development cycle of the weapon system" for seemingly endless rises in weapon system acquisition costs [Jan P. Muczyk, "On the Road Towards Confirming Augustine's Predications and How to Reverse Course," *Defense Acquisition Review Journal*, December 2007, 465-66]. Similarly, W. Blair Haworth calls the top brass's demand for increased capability without tradeoffs "capability greed" [W. Blair Haworth, *The Bradley and How It Got That Way: Technology, Institutions, and the Problem of Mechanized Infantry in the United States Army* (Westport, CT: Greenwood Press, 1999), 3].

[164] Deloitte Consulting, "Can we afford our own future? Why A&D programs are late and over-budget — and what can be done to fix the problem," 2009, 5, http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/US_AD_CanWeAffordOurOwnFuture_0127.pdf .

[165] Paul Kaminski, "Rules of Acquisition," *Defense Technology International*, October 2011, 61.

Similarly, the JSF's rising unit price and decreasing volume led one defense analyst to decry, "This is a vicious cycle, as each decline in purchases reduces economies of scale, which in turn raises prices, which in turn results in more reductions in purchases."[166]

The track record of the JSF, a fifth-generation fighter, suggests that the upward spiral of ever-increasing cost and complexity gets more vicious with each generation. This happens for two reasons. First, from an engineering perspective, it gets progressively more difficult to glean performance improvements from mature, legacy technology. Because the services have clung fervently to the canonical weapon platforms and configurations of World War II, they end up shoving, cramming, and molding technological improvements to fit into the nooks and crannies of 1945-era platforms.[167] Second, the vicious cycle gets more vicious with time because the enemy adapts and develops countermeasures to existing weapons. As a result, each sustaining innovation must develop more complex systems to overcome an enemy's countermeasures. Each generation of legacy technology needs to devote more and more of its resources to simply surviving in an increasingly hostile and sophisticated environment, let alone satisfying the requirements for even greater capability demanded by the dominant subculture(s) of each service.[168] To make matters worse, the costs associated with defensive measures to defeat an enemy's countermeasures are usually grossly out of proportion to the enemy's investment.

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[166] Paul Kallender-Umezu, "Japan May Cancel F-35 Buy if Costs Rises," *Defense News*, 27 February 2012, 4.
[167] Edward N. Luttwak, "Breaking The Bank: Why Weapons Are So Expensive," *American Interest,* September-October 2007, http://www.the-american-interest.com/article.cfm?piece=323. Even the B-2's futuristic-looking flying wing design has its origins in the WWII-era. The YB-35, a propeller-driven flying wing, similar to the B-2, flew in June 1946. A jet-powered version, the YB-49, flew a little over a year later in October 1947.
[168] For example, the B-2's stealthy design, required to improve survivability in a high-threat environment, is a huge factor in its high purchase and operating costs. The B-2 had the most expensive price tag of any bomber in the history of the U.S. Air Force; it also, according to the General Accounting Office, is "by far, the most costly bomber to operate on a per aircraft basis" ["The Gold Plated Hangar Queen Survives," Strategyworld.com, 14 June 2010]. The plane costs over three times as much to operate as the B-1B and over four times as much as the B-52H [Ibid]. Operating stealth aircraft, required to survive in an increasingly hostile and sophisticated environment, is expensive. See Chapter 5.

The tank provides a good example. Each generation of armor officers has demanded incremental improvements over the WWII design while simultaneously refusing to seriously consider any other configuration; today's battle tanks are burdened with ever-more active and passive defenses against anti-tank missiles that cost less than a hundredth of those devices.[169]

Christensen's research identifies a second pattern that also characterizes weapon system innovation. He finds that many disruptive innovations follow a common pattern of adoption, which helps explain how they can blossom. Christensen's research reveals that disruptive innovations typically underperform, at least initially, when judged against existing products, but offer benefits that appeal to those not served well by sustaining innovations.[170] Disruptive innovations tend to provide "good enough" capability for low-end users and/or offer a whole new population access to a capability it previously did not enjoy.[171] As a result, the disruptors often take root serving secondary, fringe, or niche markets and then performance improvements allow them to encroach on mainstream markets.[172] The equivalent in a military context is for new classes of weapons to first fulfill peripheral roles and then graduate to core

[169] Ibid.
[170] Clayton M. Christensen, *Innovator's Dilemma*, First Collins Business Essentials ed. (New York, NY: HarperCollins, 2006), xv.
[171] Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution* (Boston, MA: Harvard Business School Press, 2003), 102. For example, early firearms flourished by giving a whole new population access to a capability that was previously preserved for those with a lot of money or a lot of skill. Even though early firearms had worse range, accuracy, reliability, and rates of fire than longbows, they essentially allowed anyone to become a modestly effective solider after receiving very little training, whereas bow-and-arrow employment required specialists with years of practice. The arquebus, an early muzzle-loading weapon, could not compete with the longbow in terms of traditional performance measures. A well-trained archer could fire ten arrows a minute with reasonable accuracy up to 200 meters, whereas a soldier shooting an arquebus was accurate only up to 100 meters and took several minutes to reload. Instead of requiring years of training, a few days and a good drill sergeant sufficed to train a reasonably good arquebusier [Geoffrey Parker, *The Military Revolution: Military Innovation and the Rise of the West, 1500-1800* (Cambridge, UK: Cambridge University Press, 1996), 17].
[172] Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution* (Boston, MA: Harvard Business School Press, 2003), 102.

missions, progressively displacing existing weapon systems commensurate with the rate at which their relative advantage evolves.

This pattern of adoption helps explain how disruptive innovations can overcome resistance from dominant constituencies wedded to existing weapon systems. First, gaining a foothold while performing secondary roles boosts trialability and observability, two important perceived attributes. The ability to test an innovation in peacetime exercises or in war reduces the perceived risk of adopting it; the outcome makes the probability of receiving anticipated net benefits more certain, which boosts a disruptive innovation's expected value.[173] Likewise, observing either a sister service or another country's military enjoy success while employing a new weapon reduces the uncertainty associated with adopting it, thereby increasing its expected value. As Carl von Clausewitz recognized, "If, in warfare, a certain means turns out to be highly effective, it will be used again; it will be copied by others and become fashionable; and so, back by experience, it passes into general use."[174] As a new class of weapon pass into general use, it attracts more investment, which, in turn, helps accelerate technological

[173] Coté, Rosen, and Posen fail to adequately consider the role of war in accelerating the adoption of disruptive innovations. Coté does not address the subject at all. Although Posen and Rosen recognize that shifts in the strategic situation motivate senior leaders to demand change, they fail to appreciate war's importance in accelerating the development and adoption of disruptive weapons. Posen addresses war's role in innovation only to the extent that it spurs civilians to intervene. Rosen makes allowances for a faster pace of innovation during war, but he essentially dismisses its overall importance. First, he states, "Not as much time is needed to overcome the kind of organizational resistance normally found in peacetime [Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 181]. One sentence later, he equivocates. Referring to the four wartime case studies he explored, Rosen declares, "It still took a long time for the services to innovate and the payoff came late in the war and was of limited value" [Ibid]. On the next page, he concludes, "Wartime innovation is so terribly difficult" [p. 182]. Any change in the strategic situation will affect the expected value of an innovation, making it more or less attractive. Moreover, armed conflict plays a special role in the innovation process in that it increases the intensity of demand for disruptive innovation. In contrast to peacetime, when there can be tremendous difficulty in forecasting the value of new weapons, wars afford the opportunity to test and observe the results of new technology, which reduces the uncertainty associated with adopting it. Success in combat breeds more demand for the innovation.

[174] Carl von Clausewitz, *On War*, edited and translated by Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1989), 171.

advances, improving a weapon's performance and relative advantage.[175] It is important to note, however, that technological advances that benefit new classes of weapons can, but do not always, come from military R&D.[176] Alternatively, advances can also inadvertently benefit from R&D conducted in support of existing weapons.[177] Second, entering service in secondary roles can allow disruptive technologies to demonstrate their worth before they are perceived as threats to the existing weapon system. Furthermore, taking root performing peripheral roles means that disruptive innovations may not necessarily compete, at least initially, with existing weapons that define a military organization's essence. Indeed, disruptive systems sometimes

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[175] The idea that the relative advantages of disruptive innovations are largely dependent on technological advancements that enable performance improvements has its roots in the research of Giovanni Dosi, a business innovation scholar. Dosi explored "trajectories of technological progress" [Giovanni Dosi, "Technological Paradigms and Technological Trajectories," *Research Policy*, Vol. 11, Issue 3, June 1982, 147-162]. He defines the term *technological trajectory* as the "pattern of 'normal' problem solving activity (i.e., of 'progress') on the ground of a technological paradigm" [p. 152]. Clayton Christensen subsequently developed Dosi's idea in several articles and books. Although Christensen does not formally redefine the term, he discusses the sustaining and disruptive innovation's technological trajectories in a slightly different manner than Dosi. Christensen analyzes the "trajectories of performance improvement" of sustaining and disruptive innovations [Clayton M. Christensen, *Innovator's Dilemma,* First Collins Business Essentials ed. (New York, NY: HarperCollins Publishers, 2006), 26]. Although Christensen does not make the connection, inherent in the idea of a disruptive "technological trajectory" is Thomas P. Hughes's notion of "technological momentum" [see Thomas P. Hughes, "Technological Momentum" in *Does Technology Drive History?: The Dilemma of Technological Determinism*, eds. Merritt Roe Smith and Leo Marx (Boston, MA: Massachusetts Institute of Technology, 1994), 101]. Hughes suggests that the relationship between technology and society starts with a social constructive model (society shapes technology) but evolves into a form of technological determinism (technology shapes society) over time and as a technology's use becomes more prevalent and important. Societal factors may block disruptive technology from taking root, except perhaps in a niche role. But it gains momentum as the technology blossoms and the innovation encroaches on more and more markets.

[176] For example, two bicycle-shop owners, Wilbur and Orville Wright, invented powered aircraft. Moreover, manned aviation has had much of its technological progress underwritten by commercial markets. Similar to the first aircraft, the tank also has civil origins During World War I, soldiers needed a "war machine robust enough to crush barbed wire and withstand enemy fire, yet agile enough to traverse the trench-filled terrain of no man's land. The inspiration for this armored behemoth was the American tractor" [Ibid]. Tanks descended from the caterpillar tractor, invented in 1904 by Benjamin Hold to allow heavy farming machinery to traverse steep, muddy inclines of fertile river deltas using "track shoes" made from wooden planks [Mark Strauss, "Ten Inventions That Inadvertently Transformed Warfare," Smithsonian.com, 19 September 2010, available at http://www.smithsonianmag.com/history-archaeology/Ten-Inventions-That-Inadvertently-Transformed-Warfare.html?c=y&page=3]. Likewise, the steamship was invented for commercial reasons, but, in due course, transformed naval warfare. Two other examples, although not weapon systems, include railroad technology and the telegraph; both were first developed for commercial markets and only later co-opted for military use.

[177] For example, the U.S. military developed the Global Positioning System (GPS) to provide existing weapon systems, most importantly those that formed the nuclear triad, with a tool for precise navigation, yet the technology proved absolutely critical in enabling viable unmanned aircraft operations (see Chapter 5).

complement and improve the effectiveness of existing weapons, as was the case with early naval aircraft used as artillery spotters for battleships. After demonstrating their value, progressive technological improvements subsequently allow disruptive innovations to expand their role.

Consider, for example, the adoption pattern of early manned aircraft. After watching an aerial demonstration on the eve of World War I, French General Ferdinand Foch, the future commander of Allied forces, declared, "That is good sport, but for the Army the aeroplane is worthless."[178] High-ranking British military leaders came to the same conclusion. British General Sir Douglas Haig dismissed the notion that airplanes could displace cavalry in performing reconnaissance; he told to the British Army Staff College in 1914, "I hope none of you gentlemen is so foolish as to think that aeroplanes will be usefully employed for reconnaissance from the air. There is only one way for a commander to get information by reconnaissance, and that is by the use of cavalry."[179] British cavalry officers likened the idea of using aircraft in lieu of the horse to dropping a bone to catch a shadow.[180] Moreover, they fretted that airplanes would frighten their horses. The reaction of senior American military officers largely mirrored that of their European counterparts, and as a result, the United States did not own a single combat aircraft when it declared war on Germany in April 1917.[181]

At the beginning of the WWI, as a British General recalled, "Each country threw in a handful of machines as the untried, but immediately proven handmaid of reconnaissance."[182]

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[178] Basil H. Liddell Hart, *A History of the World War, 1914–1918* (London, UK: Faber & Faber Limited, 1934), 457.
[179] Quoted in Frederick Sykes, *From Many Angles* (London, UK: Harrap, 1942), 105.
[180] Walter A. Raleigh and Henry. A. Jones, *The War in the Air* (Oxford, UK: The Clarendon Press, 1922), 138.
[181] Vincent J. Esposito, Ed., *A Concise History of World War I* (New York, NY: Praeger Publishers, 1964), 256.
[182] Fredrick H. Sykes, "Air Defence," in *The Edinburgh Review or Critical Journal* 236, ed., Harold Cox (New York, NY: Longmans, Green & Co., 1922), 211.

As a result, aircraft attracted investment, which led to technological advances and expanded roles, to include aerial bombardment and attack. The following passage describes how technological advances enabled early aircraft to perform expanded combat roles:

> In 1914 the average horse-power per machine was 83, the maximum speed 74 miles per hour, and the load about 600 lbs; by 1918 the average horse-power was 516, the speed had increased to 111 miles per hour, and the load, including fuel for 5/12 hours, to 2,750lbs. At the beginning of the war an air vessel had little to fear above 4,000 feet, and its armament consisted of a rifle or revolver; at the Armistice a single-seater fighting craft carrying several machine guns, had a speed of 121 miles per hour and could climb to 23,000 feet, up to 20,000 feet of which there was no immunity from anti-aircraft fire. In 1918 low-flying attack was taking a very important part owing to the evolution of a powerfully armed machine with a speed of 125 miles per hour, and protected by 650 lbs. of armour-plate. In addition to the enormous growth of effort in direct tactical co-operation with army and navy, 1918 also saw the inception of airpower in the form of a strategic fleet of bombardment.[183]

By the end of the war, the "handful of untried machines" morphed into a fleet of thousands. On September 12, 1918, the Allies massed 1,476 airplanes under the command of the First U.S. Army Air Service and sent them to attack a troublesome and persistent salient in the western front near St. Mihiel, France.[184] The Central Powers responded with a force of 500 aircraft, and a massive aerial battle ensued.[185] Allies pilots prevailed, and for four days, severely mauled the German army, helping to reduce the bulge in the lines. The victory helped reduce uncertainty regarding the aircraft's potential in war, helping the new weapon win supporters. For example, after the war, General Foch, despite his initial apathy to aviation, declared, "One of the great factors in the next war will be aircraft obviously. The potentialities of aircraft attack on a large scale are almost incalculable."[186]

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[183] Ibid, 212.
[184] William Mitchell, *Skyways: A Book on Modern Aeronautics* (Philadelphia, PA: Lippincott, 1930), 261.
[185] William Mitchell, *Memoirs of World War I (*New York, NY: Random House, 1960), 240.
[186] Quoted in Fredrick H. Sykes, "Air Defence," in *The Edinburgh Review or Critical Journal* 236, Ed., Harold Cox (New York, NY: Longmans, Green & Co., 1922), 213. Perhaps General Foch's background as an artilleryman

While success performing secondary roles can win converts and bolster "willingness to cannibalize" among key decision makers, resistance can also stiffen among subcultures who derives their identities from existing weapons threatened by the adoption of disruptive innovations.[187] Typically, they react to the emergence of new classes of weapons in a consistent manner. First, they dismiss the potential of a new technology. Next, after a disruptive innovation gains a foothold performing secondary roles, they disparage it, predictably claiming that the nation should stick with tried-and-true weapons rather than take a chance on new and uncertain technologies.[188] If that does not work and it becomes increasingly clear that the disruptive innovation will graduate from performing peripheral to core missions, incumbents often insist the new weapon is best used in conjunction with existing ones. In other words, they claim that the disruptive innovation will supplement rather than replace an existing weapon.

Cavalry officers, for example, became particularly recalcitrant towards mechanization.[189] In 1928, General Herbert B. Crosby, the army's chief of the cavalry, proclaimed, "Tanks, tankettes, armored cars, armored airplanes, smoke projectors, gas, and all modern means of warfare in use or still to be adopted cannot take the place of the men and the horse."[190] When President Herbert Hoover ordered a study of whether motor vehicles could replace the Army's

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helped him to eventually recognize the potential of manned aircraft in war. It is not surprising, however, that he only did so after retiring from active military service.

[187] Note: the adoption of disruptive new classes of weapons does not necessarily lead to the complete displacement of existing weapons, but it does tend to lessen their role and importance.

[188] Usually, this banter is accompanied by a barrage of criticism designed to denigrate the budding technology. For example, knights, and indeed the European establishment, reacted to the emergence of early firearms by calling them "Satan's own special creations" [Martin van Creveld, *The Transformation of War* (New York, NY: The Free Press, 1991), 82].

[189] The U.S. Army first used tanks in support of the infantry.

[190] David Johnson, *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army, 1917-1945* (Ithaca, NY: Cornell University Press, 1998), 125.

beloved horses, Crosby predictably insisted that the cavalry was too valuable to be cut. When that did not work, he suggested that the debate should not be a "cavalry *or* machine" question, but instead it should address how best new technology could supplement warfare on horseback. He tried to argue that mechanization would be largely incremental and complementary rather than threatening to his branch's core operating model. He claimed the creation of "any new arm would seem to be premature" and that armored vehicles such as tanks should take on a supporting role within the cavalry since "the machines' speed and radius of action would complement the horse's flexibility."[191] The Army's last chief of cavalry, Major General J. K. Herr argued in 1939, "We must not be led to our own detriment to assume that the untried machine can displace the proved and tried horse."[192] Herr remained dogged in his conviction that the cavalry was not only a viable alternative to mechanization, but that it remained a strategic necessity. Even the German military's massacre of the Polish cavalry in 1939 could not convince him otherwise. It made him only more strenuously defend the antiquated horse force.[193] In 1942, he sent a blistering memorandum to his boss demanding that he devote more of the nation's resources to fielding mounted troops: "I am well aware of the known hostility of the Commanding General, Field Forces to horse cavalry. Nevertheless, in the interests of National Defense in this crisis, I urge upon you [General George C. Marshall] the

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[191] Ibid, 126

[192] General Herr's remarks are similar to the Navy establishment's view about the adoption of aircraft carriers. In 1920, the Navy General Board declared, "It would be the height of unwisdom for any nation possessing sea power to pin its faith and change its practice upon mere theories as to the future development of new and untried weapons" [Lee P. Warren, "The Battleship Still Supreme: Why Neither Aircraft Nor Submarine Has Yet Replaced the Capital Ship in Its Master of the Sea" in *The World's Work: A History of Our Time* Vol. XLI (November 1920 to April 1921), Eds. Walter Hines Page and Arthur W. Page (Garden City, New York: Doubleday, Page & Company, 1920-1921), 556.

[193] David Johnson, *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army, 1917-1945* (Ithaca, NY: Cornell University Press, 1998), 139.

necessity of an immediate increase in horse Cavalry."[194] After his retirement, Herr unapologetically continued his unwavering advocacy of the cavalry, suggesting that horses may have been the key to securing victory in the Korean War in the early 1950s. He insisted a stalemate in Korea would not have been possible if the United States had retained a "really mobile cavalry, mounted on horses and trained to fight on foot."[195]

CONCLUSION

This chapter proposes a new, cross-disciplinary framework to describe airpower-related weapon system innovation. It asserts that the U.S. armed forces perennially pursue sustaining innovation because they characteristically offer greater relative advantages over disruptive innovations. Nevertheless, the services, on occasion, adopt disruptive innovations. The model acknowledges that interservice competition and changes in a state's security situation, two factors identified in doctrinal innovation literature as drivers of innovation, can sway decision makers. However, it maintains, per a central finding of diffusion of innovations (DOI) research, that the perceived attributes of innovations also weigh heavily in decisions to adopt disruptive innovations. Based on insights from Clayton Christensen's disruptive innovation theory, the model suggests relative advantage can evolve to favor new classes of weapons over existing ones. To test whether the new, cross-disciplinary framework adds explanatory power, Chapters 3-5 investigate the following cases: the adoption of the intercontinental ballistic missile (ICBM), the helicopter, and the UAV.

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[194] Ibid, 105.
[195] John K. Herr and Edward S. Wallace, *The Story of the U.S. Cavalry* (Boston, MA: Little, Brown and Company, 1953), 225.

CHAPTER 3

INTERCONTINENTAL BALLISTIC MISSILES

"When you can put something on that missile bigger than a f***ing firecracker, come and see me."[196]

— General Curtis LeMay, Commander of Strategic Air Command

This chapter investigates the U.S. Air Force's adoption of the intercontinental ballistic missile (ICBM). First, it presents a historical narrative discussing events and factors that stimulated the service to adopt the ICBM. Next, it compares the explanatory power of Barry Posen, Stephen Rosen, and Owen Coté's theories with that offered by the new, cross-disciplinary framework proposed in this study. The case reveals that the latter adds value.

ICBM HISTORY

Emergence

Modern ballistic missile history picks up with the work of Dr. Robert Goddard, an American physics professor who experimented with rockets in the early twentieth century.[197]

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[196] Quoted in Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 413.

[197] Jacob Neufeld, "Ace in the Hole: The Air Force Ballistic Missiles Program," *Technology and the Air Force: A Retrospective Assessment*, Eds. Jacob Neufeld, George Watson, and David Chenoweth (Washington, DC: Air Force History and Museums Program, 1997), 112. Although other scientists besides Goddard conducted rocket research in

At the end of World War I, Goddard approached both the U.S. Army and Navy asking for financial support for his research, but he failed to interest either service.[198] The U.S. military establishment, in the words of one historian, viewed Goddard as a "freak."[199] Undeterred, Goddard persisted in his quest for funding and managed to entice a civilian organization, the Smithsonian Institute, to give him money for experiments. In 1926, he designed and flew the world's first liquid-fueled rocket, a significant event in the history of the ICBM because Germany's military scientists used the design to power the V-2, the ICBM's predecessor.[200]

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the early twentieth century, he was the first to launch a liquid-fueled rocket, the same technology used in the V-2 (see discussion later in the chapter regarding the importance of the V-2). Note: rockets were invented in China sometime between 1000 and 1150 AD. First used for firework displays during festivals, rocket technology spread westward and within a century or two was known to all major Eurasian civilizations. Rockets soon found military applications; however, their technological immaturity meant that they were marginally effective. As a result, they are footnotes in texts describing medieval battles. In Europe, the use of rockets in war all but disappeared with the adoption of primitive firearms in the fourteenth century. Elsewhere, non-European armies continued to employ rockets, but only sporadically, and their use rarely affected a battle's outcome. At the start of the nineteenth century, the British re-discovered rockets after suffering casualties from Indian cast-iron rockets, a technological improvement that greatly improved rocket performance over previous designs made from bamboo and/or pasteboard. The British sent captured rockets home and William Congreve, an inventor, improved the design. The British subsequently re-introduced rockets into their arsenals and other western nations quickly followed suit. Rocket technology, however, remained immature and vastly underperformed relative to other traditional artillery weapons like the cannon. Whereas cannons could be aimed with reasonable accuracy, Congreve rockets, although improved over earlier designs, remained wildly inaccurate and unreliable. Their imprecise directional control led to wide and random patterns of dispersion. To help mitigate this deficiency, the standard operating procedure was to use rockets solely as a barrage weapon and in large numbers. That tactic, however, proved only marginally helpful. What is worse, the erratic and unpredictable flight paths of Congreve rockets often caused casualties among the side responsible for launching the attack. Launching a large number in great barrages caused fratricide, an unintended consequence. Here is how one British soldier described the effectiveness of rockets in 1813: "[The rocket] is a very uncertain weapon. It may, indeed, spread havoc among the enemy, but it may also turn back upon the people who use it, causing, like the elephant of other days, the defeat of those whom it was designed to protect" [Gareth Glover, "History of the Rocket - 1804 to 1815," http://napoleonic-literature.com/Articles/Rockets/History_of_Rockets.htm]. The use of rockets in war petered out in the 1870s and essentially lay dormant until Dr. Goddard's research. For a concise history, see A. Bowdoin Van Riper, *Rockets and Missiles: The Life Story of a Technology* (Westport, CT: Greenwood Press, 2004).

198 Jacob Neufeld, "Ace in the Hole: The Air Force Ballistic Missiles Program," *Technology and the Air Force: A Retrospective Assessment*, Eds. Jacob Neufeld, George Watson, and David Chenoweth (Washington, DC: Air Force History and Museums Program, 1997), 112.

199 Martin van Creveld, *Technology and War: From 2000 B.C. to the Present* (New York, NY: Free Press, 1989), 221.

200 The "V" designation comes from the German word *Vergeltungswaffe*, which means "vengeance weapon." Adolf Hitler bestowed the designation on the V-1, a pulse-jet-powered cruise missile, and the V-2. Note: the V-1's technical designation was the Fiesler Fi-103, and the V-2's technical designation was the Aggregat-4.

Unlike the American military officials who thought Goddard was a "freak," German military scientists closely monitored Goddard's research and used his ideas in their crash development of the V-2 during World War II.[201] Why, one asks, should the V-2 have been a German development when an American developed the liquid-fueled rocket design?[202] The U.S. military failed to foresee the significance of Goddard's achievement because missile technology, still in its infancy, offered it few advantages over traditional bombardment weapons at its disposal. In contrast, restrictions placed on Germany by the Treaty of Versailles, the peace settlement that ended World War I, gave it few options for deep strike. Under the provisions of the treaty, Germany was prohibited from maintaining an air force and a navy. The peace agreement also prohibited German arms manufacturers from producing field guns with bores larger than 170 millimeters. Tanks offered a way to penetrate the front lines of enemy troops, but tanks of the day travelled at speeds slightly faster than infantry could march. This left Germany without the ability to hit the enemy's rear echelons and heartland.[203] Looking for

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[201] Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 5.

[202] Ibid. Barry Posen, Owen Coté, and Stephen Rosen's theories fail to adequately answer this question. Barry Posen says civilian intervention is the source of innovation, but Adolf Hitler was an obstacle rather than the driving force in the V-2's adoption. Hitler embraced the technology after he had no other option and too late in the war to make a difference [G. Harry Stine, *ICBM: The Making of the Weapon that Changed the World* (New York, NY: Orion Books, 1991), 60]. The German army, not the country's civilian leaders, pushed for the development of this innovative weapon. Coté suggests interservice conflict sparks military innovation, yet there is no evidence that interservice competition spurred the development of the V-2. Hermann Göring, the Commander-in-Chief of the Luftwaffe, did not obstruct the Wehrmacht-sponsored missile program, nor did its existence compel him to order the service to develop a competing program. Lastly, Rosen's theory, like the other two, fails to adequately explain when and why the German military developed the V-2. Rosen claims that innovation occurs only when the established order within a service is internally uprooted by those with different ideas and priorities; hence, the creation of new promotion paths to senior ranks is indispensable [Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 20]. As a result, Rosen claims innovation occurs at a generational pace, proceeding "only as fast as young officers rise to the top" [Ibid, 105]. Although his theory is insightful, when it comes to the V-2, Rosen's model does not match the historical record. First, the development and adoption of the V-2 did not occur at a generational pace. It was the result of a crash wartime program that occurred very quickly, exactly opposite of the glacial pace that Rosen predicts. Second, the German military made no changes in promotion paths to facilitate the development of the V-2.

[203] G. Harry Stine, *ICBM: The Making of the Weapon that Changed the World* (New York, NY: Orion Books, 1991), 13.

ways to skirt legal restrictions imposed on it by the Versailles Treaty, the German army sponsored rocket research in the 1930s that would give its scientists a technical foundation enabling it to rain nearly 3,000 V-2s down on European cities in a last-ditch effort to reverse the course of the war.[204]

The Battle of Britain, fought during the summer and autumn of 1940, savaged Luftwaffe aircraft and aircrew. In the years that followed, the Allied bombing campaign pounded German airfields and fuel depots. Meanwhile, Allied fighter operations extracted a devastating toll on the Luftwaffe. As a result, even if Germany had somehow managed to save more fuel stockpiles, it lacked sufficient number of experienced pilots to effectively counter Allied strength in the air. Enthralled by the promise of a high payoff, Adolf Hitler ordered the crash production of the V-2 in 1943 in an attempt to throw a "game-changing" technological Hail Mary at the Allies. The decision was made easier by the fact that Allied victories meant the choice was increasingly no longer between traditional manned airpower and ballistic missiles. Rather, it was between embracing the disruptive innovation and, to use a business term, the "non-consumption" of airpower. Technical delays and materiel shortages delayed its fielding; the first V-2 was fired against the Allies in September 1944. Responding to a terrorized British public, the Allies spent considerable resources bombing Germany's missile production and launch facilities, hoping to target the missile before flight. After launch, the Allies had little defense against the supersonic missile, which dropped on their cities from the stratosphere.

[204] Germany also launched 10,000 V-1s at the Allies in a last-ditch attempt to reverse the course of the war.

Teetering on a Breakout, But Technologically Immature

At the end of World War II, ballistic-missile technology seemed promising. Both the Soviets and the Americans rushed to capture German scientists, the inventory of German V-2 rockets that had yet to be fired, and any research documents they could find. General Henry H. "Hap" Arnold, Commanding General of the U.S. Army Air Forces (USAAF), predicted, "The next war may be fought by airplanes with no men in them at all" (see quote in the Introduction)[205] By 1946, under Arnold's leadership, the USAAF had initiated twelve guided-missile programs, including Convair's MX-774, a missile that would eventually evolve into the Atlas, America's first operational ICBM.[206]

Arnold's vision, however, was premature. It took fourteen more years before the U.S. Air Force would field the Atlas as an operational missile. Ballistic-missile technology was too immature and simply could not compete with the sustaining alternative, the manned bomber, a weapon that had twice proven its ability to accurately deliver nuclear payloads. Early ICBM prototypes, developed as part of the MX-774 program, were essentially copies of the V-2. Even though the V-2 represented a major technological achievement, the missile was notoriously inaccurate and unreliable.[207] It was able to achieve no tighter "circular error probable" (CEP) than fifteen kilometers, and that was after German engineers completed 65,000 design modifications.[208] During WWII, V-2s were launched from less than 200 miles from London, yet succeeded in hitting the massive city only forty percent of the time. Dr. Wernher von Braun,

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205 Quoted in Jay M. Shafritz, *Words on War: Military Quotes from Ancient Times to the Present*, (New York, NY: Prentice Hall, 1990), 104.
206 John T. Correll, "How the Air Force Got the ICBM," *Air Force Magazine*, July 2005, 69.
207 Andrew L. Dunar, "Wernher von Braun: A Visionary as Engineer and Manager," *Realizing the Dream of Flight: Biographical Essays in Honor of the Centennial of Flight, 1903–2003,* Eds. Virginia P. Dawson and Mark D. Bowles (Washington, DC: National Aeronautics and Space Administration, 2005), 190.
208 Jeremy Stocker, *Britain and Ballistic Missile Defence, 1942-2002* (New York, NY: Frank Cass, 2004), 9.

the German scientist who designed the V-2 and later became head of the U.S. Army's rocket program, recalled how poorly the V-2 performed: "Our main objective for a long time was to make it more dangerous to be in the target area than to be with the launch crew."[209] American engineers tried to improve the missile's accuracy and reliability, but even after their tinkering, launch crews were still in more danger than targets. Several test flights conducted as part of the MX-774 program crashed before getting very far off their launch pads, and it became quickly apparent that significant technical challenges needed to be overcome before ICBMs would became a reality.[210]

Initial specifications for the MX-774 called for it to carry a 5,000-pound atomic warhead 5,000 miles and strike within a mile of the target.[211] The weight requirement was calculated based on the designs of early atomic bombs, which were quite bulky and exceedingly heavy. Scientists joked that designing a missile to carry a payload that size essentially meant it needed to be the "size and configuration of the Empire State Building."[212] Moreover, achieving the level of accuracy specified in the MX-774's initial requirement was an illusion. Given the ballistic accuracy of the day, an ICBM that traveled 5,000 miles might come down 75 miles from its intended target.[213]

After experiencing serious health issues, General Arnold handed over command of the soon-to-be-independent Air Force to General Carl Spaatz in 1946. Spaatz and his successor General Hoyt Vandenberg did not share Arnold's enthusiasm for an unmanned future for

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[209] Quoted in Major General John B. Medaris with Arthur Gordon, *Countdown for Decision* (New York, NY: G. P. Putnam's Sons, 1960), 37-38.
[210] John T. Correll, "How the Air Force Got the ICBM," *Air Force Magazine*, July 2005, 70.
[211] Ibid, 69.
[212] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 154.
[213] John T. Correll, "How the Air Force Got the ICBM," *Air Force Magazine*, July 2005, 69.

airpower. Arnold's attitude about unmanned airpower and reaction to Germany's use of the V-weapons during World War II compared with that of Spaatz and Vandenberg was foretelling. In 1943, anticipating the coming importance of missiles, General Arnold, remarked, "Someday, not too far distant, there can come streaking out of somewhere—we won't be able to hear it, it will come so fast—some kind of gadget with an explosive so powerful that one projectile will be able to wipe out completely the city of Washington … I think we will meet the attack alright and, of course, in the air. But I'll tell you one thing, there won't be a goddam pilot in the sky! That attack will be met by machines guided not by human hands, but by devices conjured up by human brains."[214] Arnold believed the future relevance of the Air Force depended on how well it adjusted to scientific and technological advances. When the Germans started firing their V-1s and V-2s at the Allies in 1944, General Arnold wanted the U.S. Army Air Forces to develop their own missiles to match the enemy's capability.[215] In contrast, Generals Spaatz and Vandenberg foresaw no immediate requirement for the use of pilotless aircraft and were against the proposal.[216] Indeed, few if any Air Force leaders shared Arnold's vision. The consensus among Air Force leaders was that missile technology, if it did become viable, was many years away from practical utility.[217]

Accordingly, ICBM development effectively ground to a halt under Spaatz and Vandenberg's leadership. Facing post-war budget cuts and aware of the technical challenges the ICBM had yet to conquer, Spaatz slashed the Air Force's missile development budget by

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[214] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 35.

[215] Jacob Neufeld, "Early Experimental Guided Missiles," *Air Power History* 58, Vol. 1, Spring 2011, 33.

[216] Ethel M. DeHaven, *Aerospace: The Evolution of USAF Weapons Acquisition Policy, 1945-1961* (Los Angeles, CA: Deputy Commander for Aerospace Systems Historical Office, 1962), 7.

[217] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 24.

more than fifty percent, from $29 million to $13 million. As part of those cuts, Spaatz also cancelled the MX-774 program, only a year after it was initiated. Told to expect more budget cuts by President Harry Truman, Spaatz directed the Air Staff to evaluate and rank order the service's various missile programs. The Air Staff concluded, "In the wake of America's rapid and extensive demobilization, the atomic bomb constituted the nation's main source of power and the subsonic [manned] bomber its only means of delivery over the next ten years."[218] As a result, it ranked air-to-air and air-to-surface missiles, technologies that helped bombers penetrate enemy air defense and return safely, at the top of its research and development (R&D) priority list. The Air Staff placed the development of long-range surface-to-surface missiles near the bottom of its priority list, ranking it below even the development of short-range, tactical surface-to-surface missiles designed for use as Army artillery.[219] The Air Staff also made clear that it favored the ground-launched cruise missile over the ICBM if a nuclear-delivery platform other than the manned nuclear bomber was to be pursued.[220] Agreeing with the Air Staff's assessment, Spaatz cancelled the ICBM program.

Suffering from health issues, Spaatz served a relatively short stint as chief of staff and was succeeded by General Hoyt Vandenberg in July 1948. Vandenberg did nothing to reverse Spaatz's course. During Vandenberg's tenure as the chief of staff of the new Air Force, ICBM

[218] Ibid, 27.
[219] John T. Correll, "How the Air Force Got the ICBM," *Air Force Magazine*, July 2005, 69.
[220] Ibid. "It is not surprising that [Air Staff] planners, faced with austere budgets and technological uncertainty, placed their trust in the familiar and proven subsonic bomber, and looked to missiles to augment manned aircraft rather than to replace them" [Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 27].

research and development (R&D) proceeded, in the words of Dr. Edward Teller, the chief U.S. advocate of the hydrogen bomb, at an "exceedingly slow and small rate."[221]

From both a technological and organizational perspective, the Air Force leadership's decision to cancel its nascent ICBM program and strengthen its commitment to the nuclear bomber, a weapon system that helped earn the Air Force its independence, was a rational decision. At the time, ICBM technology offered worse performance than nuclear bombers. Although a missile could conceptually beat a bomber to the target, there was no guarantee that an ICBM would land anywhere close to the intended target. Serious technical challenges remained, and it was uncertain whether ballistic-missile technology would ever become viable, let alone offer greater relative advantage than the manned nuclear bomber, a technology that had already convincingly demonstrated its destructive power. Dr. Edward Teller remarked, "We did not start a vigorous development because it could not be proven that these missiles [would] be really important."[222] Likewise, General Bernard Schriever, a driving force behind the Air Force's eventual adoption of the ICBM, explained in a 1957 interview that Air Force leaders assessed the ICBM to offer "questionable military value based on the then state of the art, so we sort of put it on the back burner."[223] Similarly, during 1956 congressional testimony, Trevor Gardner, Special Assistant to the Secretary of the Air Force for Research and Development, in response to a question from Senator Stuart Symington on why the Air Force chose not to develop and field a long-range surface-to-surface ballistic missile after WWII, remarked, "I think

[221] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 504.
[222] Ibid, 504.
[223] "ARMED FORCES: The Bird & the Watcher," *Life Magazine*, 1 April 1957, available at http://www.time.com/time/magazine/article/0,9171,867552-1,00.html.

it was because it didn't look like it was worth the game."[224] He went on to qualify his answer, however. Gardner said that if Air Force leaders had anticipated the pace of technological progress that was achievable, then "… we could have had missiles today, there is no question about it."[225]

From an organizational perspective, the Air Force had no incentive to lean forward and pursue ICBM technology. It had just finished spending an exorbitant amount of money to develop the B-29 Superfortress, the most expensive weapon system in the history of the United States, costing more money than the Manhattan Project which developed the world's first nuclear bombs.[226] And, the service was just starting to take delivery of its next "super bomber," the B-36 Peacemaker, a mammoth aircraft that was two-thirds longer than the B-29 with the capacity to carry four times its payload. After World War II, the Air Force's manned bomber fleet gave the service a monopoly over the strategic nuclear-weapon-delivery mission; as a result, the service garnered nearly fifty percent of the country's total defense budget. Indeed, the manned nuclear bomber was precisely the capability that gave the United States a strategic advantage over its rival, the Soviet Union.[227] From a service perspective, adopting the ICBM offered a payoff no greater than the possibility of preserving its strategic nuclear monopoly, but only if the other services did not follow suit. What is worse, the adoption of the ICBM would have meant a reduction in the quantity and importance of its prized bomber fleet and threatened the "bomber mafia," the dominant subculture within the U.S. Air Force.

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[224] Senate, "Study of Airpower," Hearing Before the Subcommittee on the Air Force of the Committee on Armed Services, Eighty-Fourth Congress, Second Session, 14 June 1956, Part XIII, 1143. Trevor Gardner, a businessman, was first appointed as Special Assistant to the Secretary of the Air Force for Research and Development in 1953 and later promoted to the newly created position of Assistant Secretary of the Air Force (Research and Development).
[225] Ibid.
[226] Carl H. Builder, *The Icarus Syndrome: The Role of Air Power Theory in the Evolution and Fate of the U.S. Air Force* (London, UK: Transaction Publishers, 1994), 121.
[227] Ibid, 78.

Furthermore, sustaining innovations to develop new generations of the manned bombers did not necessarily require technological breakthroughs of the same scale required to field the ICBM, an entirely new class of weapon.

Soviet ICBM Research

While the United States military effectively sat on its hands in terms of ballistic-missile R&D for the seven-year period between 1947 and 1954, the Soviet Union aggressively pursued ICBM technology.[228] And, it did so despite facing even greater challenges than the United States. Unlike the United States, much of the Soviet industrial base was in ruins from the Nazi invasion. Additionally, whereas the United States had already developed and dropped two atomic bombs, the Soviets were just starting their nuclear-development efforts. Helped by espionage, the Soviets exploded their first atomic weapon in 1949, years before the West anticipated. By 1951, the Soviet ballistic-missile program had matured. In that year, the Soviets sent home the first wave of German rocket scientists they had forced or enticed to work out of country.[229]

Why did the Soviets aggressively pursue ICBM development, despite facing higher hurdles, while the United States punted? The following passage from *The Future of War: Power, Technology & American World Dominance in the 21st Century*, helps explain why:

[228] On paper, the U.S. Air Force revived its ICBM program in 1951. The service provided only enough funds to support "what was in effect a study program" [Senate, "Study of Airpower," Hearing Before the Subcommittee on the Air Force of the Committee on Armed Services, Eighty-Fourth Congress, Second Session, 14 June 1956, Part XIII, 1109]. "Our scientists were mostly confined to studying what we might build if money should become available," complained Trevor Gardner [Trevor Gardner, "Must Our Air Force Be Second Best?" *Look*, 1 May 1956, 80].

[229] No doubt, German scientists influenced and accelerated the Soviet missile program, but by the time the Soviet's launched Sputnik in 1957 atop the R-7, the world's first ICBM, it was purely a Russian effort [Anatoly Zak, "The Rest of the Rocket Scientists," *Smithsonian Air and Space*, 1 September 2003, http://www.airspacemag.com/space-exploration/cit-zak.html?c=y&page=5].

> The Soviets felt that they had properly analyzed the strategic threat created by the bomber, and they demonstrated this by not building bombers themselves. In part this represented a historic distrust of manned strategic bombers—the Soviets had no experience with them during World War II. In part the decision had to do with geopolitical reality. Unlike the Americans the Soviets had no bases within range of the enemy. This meant that Soviet bombers simply could not reach the United States. The Soviets did build one intercontinental bomber in the 1950s—the Bear—but the likelihood of its being able to cross the oceans or traverse the Arctic and then penetrate the American heartland was near zero. It is also important to remember that in the Soviet Union no built-in political apparatus defended the interests of a strategic bomber command, as most assuredly was the case in the United States. The Soviets were free to solve the problem in a more radical way, more in keeping with their own historical interest in artillery and rocketry. The Soviets, therefore, sought to leapfrog the manned bomber stage by developing an intercontinental missile that could deliver nuclear weapons in a matter of minutes.[230]

In other words ICBMs offered the Soviet Union a much higher relative advantage. The Soviets did not have to overcome high organizational costs associated with abandoning existing weapons in order to embrace ICBMs. In a certain respect, although the Soviets started at a technological disadvantage relative to the United States, that "disadvantage" worked in their favor because it allowed the Soviet military to approach the problem of developing a nuclear-delivery force from a fresh perspective without having to overcome entrenched interests favoring the status quo.

The U.S. Air Force Develops and Adopts the ICBM

Given how the ICBM initially offered the U.S. Air Force such a low expected value, what changed? What led the U.S. Air Force to adopt ICBMs? A confluence of several critical supporting technologies, the most important of which was the development of a hydrogen bomb (normally abbreviated "H-bomb"), helped alter the relative advantage of the ICBM vice

[230] George and Meredith Friedman, *The Future of War: Power, Technology & American World Dominance in the 21st Century* (New York, NY: Crown Publishers, 1996), 79.

the manned nuclear bomber.[231] Thermonuclear warheads not only made the ICBM much more feasible, but it also made it immensely more attractive. The H-bomb provided a high-yield, low-weight, reliable, and small warhead that could be married to a ballistic missile. Perceiving this technological development would give the ICBM an advantage over the manned nuclear bomber, three prescient leaders—Trevor Gardner, General Bernard Schriever, and General Thomas White—fought for the new weapon's adoption. Of the three, White deserves perhaps the lion's share of credit in getting the Air Force to embrace the disruptive weapon.[232] Change comes about through the actions of those in power, and although Gardner helped grease political skids and Schriever was responsible for building America's ICBM arsenal, it was White

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[231] Gimbaled engines, introduced on sounding rockets in the late 1940s, providing more precise control with less reduction of thrust than the movable vanes used on the V-2 [A. Bowdoin Van Riper, *Rockets and Missiles: The Life Story of a Technology* (Westport, CT: Greenwood Press, 2004), 73]. Gimbaled engines, coupled with more advanced accelerometers and gyroscopes to detect changes in the speed and orientation of the rocket, helped improve missile accuracy [Tae-Woo Lee, *Military Technologies of the World* (Westport, CT: Greenwood Publishing Group, 2009), 72]. The development of an ingenious mathematical scheme called the "Q-matrix," which shifted the bulk of computations requirements out of the missile, by the Massachusetts Institute of Technology (MIT) Instrument Laboratory in the early 1950s also helped improve missile accuracy [Donald A. MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Boston, MA: MIT Press, 1993) 121]. Additionally, the construction of the all-electronic digital computer (also at MIT), the first algebraic compiler, and the design of an algebraic programming language were instrumental in the development of a self-contained guidance system for the Atlas [Richard H. Battin, "Space Guidance Evolution—A Personal Narrative," *Journal of Guidance and Control*, Vol. 5, No. 2, March-April 1982, 97-110]. In 1953, National Advisory Committee for Aeronautics (NACA) aerodynamicists H. Julian Allen and Alfred Eggers's analysis suggested a blunt nose cone would help reduce heating during re-entry, thereby reducing the chance the missile would burn-up. Advances in ablative shielding on the eve of the Atlas go-ahead also contributed to a shift in the perceived relative advantage offered by the ICBM [T. A. Heppenheimer, *Facing the Heat Barrier: A History of Hypersonics* (Washington, DC: Government Printing Office, 2007), 30-42]. Note: the concept of an ablative heat shield was described as early as 1920 by Robert Goddard: "In the case of meteors, which enter the atmosphere with speeds as high as 30 miles per second, the interior of the meteors remains cold, and the erosion is due, to a large extent, to chipping or cracking of the suddenly heated surface. For this reason, if the outer surface of the apparatus were to consist of layers of a very infusible hard substance with layers of a poor heat conductor between, the surface would not be eroded to any considerable extent, especially as the velocity of the apparatus would not be nearly so great as that of the average meteor" [Robert Goddard, "Report Concerning Further Developments," March 1920, available at http://siarchives.si.edu/history/exhibits/documents/goddardmarch1920.htm].

[232] General White, to borrow an expression from President George W. Bush, was "the decider," whereas General Schriever biggest contribution lay in building America's arsenal of ballistic missiles (i.e., implementing White and Gardner's vision). Schriever shrewdly undertook all phases of the design-to-production-to-operation cycle concurrently rather than sequentially, thereby accelerating the delivery of ICBMs. Note: Stephen Rosen acknowledges, "Change will come about through the actions of those who have the power" [Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 21].

who hoisted the ICBM to the top of the Air Force's R&D priority list in May 1954 and subsequently orchestrated the service's crash development program. He used the power of his office, first as vice chief and later as chief of staff, to overcome stiff resistance from the "bomber mafia."

With few exceptions, General White being one of them, Air Force leaders had developed an absolutist perspective towards war and airpower.[233] Strategic bombing was more than just the Air Force' preeminent mission; it could more accurately be described as the service's theology.[234] Bomber generals who sat at the top of the service's hierarchy were the natural descendants of the prewar airpower enthusiasts whose central tenet held that airpower, specifically strategic bombing, not only could win wars but also could end them.[235] To achieve and justify independence, airmen needed to break free from the notion that airpower was an auxiliary arm of ground forces. Consequently, the Air Force adopted strategic bombing, a unique mission that only airmen could execute, as its reason for existence.[236] Air Force leaders believed their World War II experience validated this strategic vision, one in which the manned bomber served as the central instrument of war.[237]

Chief among the bomber generals was a rising officer named Curtis LeMay. LeMay was the leader most responsible for building the "bomber mafia" into the service's dominant

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233 Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 43. Worden borrows the term "absolutist" from Morris Janowitz, *The Professional Soldier, A Social and Political Portrait* (Glencoe, IL.: Free Press, 1960), xi.
234 Earl H. Tilford, *Crosswinds: The Air Force's Setup in Vietnam* (College Station, TX: Texas A&M University Press, 2009), ix.
235 Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 43.
236 Sanford L. Weiner, "Evolution in the post-Cold War Air Force: Technology, Doctrine, and Bureaucratic Politics" in *U.S. Military Innovation since the Cold War: Creation without Destruction*, Eds. Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman (New York, NY: Routledge, 2009), 101.
237 George and Meredith Friedman, *The Future of War: Power, Technology & American World Dominance in the 21st Century* (New York, NY: Crown Publishers, 1996), 78.

subculture.[238] It would remain the Air Force's most powerful constituency for more than thirty years, until the adoption of ICBMs weakened the bomber generals' position of power. The inspiration for the crazed General Jack D. Ripper in Stanley Kubrick's *Dr. Strangelove*, the cigar-chomping, gruff-talking LeMay was a decorated World War II officer who delivered results in both the European and Pacific theaters. He was the architect of the firebombing of Tokyo, which destroyed sixteen square miles of the city's center, and attacks on sixty-four other Japanese cities during World War II. The raids killed more than three hundred thousand people. Describing the firebombing of Toyko, the U.S. Strategic Bombing Survey stated: "Probably more persons lost their lives by fire at Tokyo in a 6-hour period than at any time in the history of man."[239] As a result of his wartime experience, the bomber became more than a weapon to Curtis LeMay, it became, in the words of one historian, "a fighting machine to which he was deeply wedded emotionally, an arm in which he had unshakable faith."[240]

After the war, LeMay served a short stint at Headquarters Air Materiel Command before being appointed assistant chief of the Air Staff for research and development, a new position created with a mandate to coordinate all AAF R&D activities. Arnold was reluctant to let LeMay lead the service's R&D efforts, but ultimately gave into Spaatz's request.[241] "No good deed

[238] For a discussion of the origins of Strategic Air Command's organizational culture, see Melvin Deaile, "The SAC Mentality: The Origins of Organizational Culture in Strategic Air Command, 1946-1962," University of North Carolina at Chapel Hill Dissertation, 2007.
[239] *United States Strategic Bombing Survey (Pacific War)*, Vol. 96, 95.
[240] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 132.
[241] Warren Kozak, *LeMay: The Life and Wars of General Curtis LeMay* (Washington, DC: Regnery Publishing, 2009), 265.

goes unpunished, as the saying goes, and Arnold's was no exception," observes Neil Sheehan, the author of a biography of General Schriever.[242] Sheehan continues:

> Like most of the rest of the bomber generals … guided missiles, and other advanced concepts held scant interest for LeMay. He wanted bigger and better bombers that could fly higher and farther and faster and carry as many as possible of the 10,000-pound Mark 3, the Nagasaki-type plutonium bomb that was to become the first standardized U.S. nuclear weapon. Research and development to a man of LeMay's outlook meant focusing on improvements to these new bombers coming on line. The B-36—a six-engine behemoth that dwarfed the B-29 at more than half the length of a football field, weighed in excess of 160,000 pounds, had a 72,000-pound bomb load, a ceiling of 40,000 feet, and a combat radius of approximately 3,500 miles—was the kind of weapon that got his attention.[243]

In October 1947, General LeMay was transferred to command the United States Air Forces in Europe where he would organize air operations for the Berlin Airlift. LeMay returned to the United States less than a year later as the leader of Strategic Air Command (SAC), a position he would hold for nearly ten years, longer than anyone in the history of the organization. He immediately convinced other senior Air Force leaders to endorse strategic bombing with its instrument of the manned nuclear bomber as the young Air Force's primary mission.[244] In October 1948, the new SAC commander gave a speech in which he proclaimed, "The fundamental goal of the Air Force should be the creation of a strategic atomic striking force capable of attacking any target in Eurasia from bases in the United States and returning to the points of take-off."[245] Two months later, the U.S. Air Force Senior Officer Board, convened on order from General Vandenberg, declared, "The launching of an atomic offensive and the

[242] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 124.
[243] Ibid.
[244] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 60.
[245] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 243.

defense of the Western Hemisphere and the essential base areas from which to launch the atomic offensive must be considered as the primary mission of the Air Force and must be given the greatest consideration and priority." [246]

Despite the Air Force's commitment to the manned bomber, which was codified in its doctrine, several events led the service to revive its ICBM program in 1951.[247] First, in 1950, a RAND Corporation study suggested that overcoming the technical challenges to develop an ICBM was feasible. Second, in 1951, alarming intelligence reports also started filtering in after the first wave of Nazi scientists who had worked on the Soviet missile program were sent home to Germany. Reports suggested the Soviets had developed a huge rocket engine (said to generate 265,000 pounds of thrust) and that they were building another engine, twice as powerful.[248] Lastly, the outbreak of the Korean War helped boost defense spending. By 1951, the Air Force's R&D budget had returned to its 1946 level. The increased R&D budget meant the Air Force had enough money to pay Convair, the MX-774's lead contractor, to conduct an engineering study of whether or not it was feasible to build a missile that could carry an 8,000-pound warhead—3,000 pounds more than the 1946 requirement—5,750 miles and strike within 1,500 feet of an intended target.[249] Convair engineers told the Air Force that they could

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[246] Ibid, 242-243.

[247] In addition to the U.S. Air Force Senior Officer Board's pronouncement, Air Force Manual 1-8, *Strategic Air Operations*, stated the manned bomber was the "primary offensive manifestation of national power in war" [George A. Reed, "U.S. Defense Policy, U.S. Air Force Doctrine and Strategic Nuclear Weapon Systems, 1958-1964: The Case of the Minuteman ICBM," Duke University Dissertation, 1986, 23].

[248] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 71. The first Soviet ICBM was designed to carry a 5.4-ton fission warhead. The missile was so huge that it could be moved only by rail, and required twenty hours to prepare for flight [Steve Call, "The Cabinet of Dr. Strangelove," review of *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* in *The New York Times Review of Books*, 25 February 2010, 2, available at http://lshea.org/lectures/docs/strangelove_nyrb.pdf].

[249] John T. Correll, "How the Air Force Got the ICBM," *Air Force Magazine*, July 2005, 71. The first standardized U.S. nuclear bomb was the Mark 3, a Nagasaki-type plutonium bomb which weighed 10,000 lbs. Although there is no mention of why the carrying capacity increased from 5,000 pounds in the original 1946 specification to 8,000 in

build an ICBM that would meet its specifications, but that doing so meant building an enormous missile, one more than 160 feet long and 12 feet in diameter.[250]

Convair's report was not enough to entice senior Air Force leaders to push beyond a paper study and into production. Instead, the Air Force stuck with the priorities that the Air Staff had outlined back in 1947. That meant that missiles were still ranked near the bottom of the R&D priority list.[251] In 1952, expenditures for all guided-missile programs equaled only 4% of the money allocated for aircraft.[252]

In November 1952, American scientists exploded their first thermonuclear bomb.[253] It is important to point out that the hydrogen bomb was not developed to make the ICBM more viable. Rather, it was the product of sustaining innovation to a weapon designed to be dropped from the manned nuclear bomber.

In 1953, then Brigadier General Schriever attended a briefing given by Dr. Jon von Neumann to the Air Force's Scientific Advisory Board. Based on the successful thermonuclear test, Dr. von Neumann discussed the possibility of building a 1500-pound nuclear bomb with a one megaton-yield. Schriever recalled how he "almost came out of my seat in excitement,

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the 1951 specification, the added weight was probably due to a realization that the first standardized U.S. nuclear weapons would weigh more than the original 1946 estimate.

[250] Forward-thinking Convair executives, rather than stop research entirely in 1947 when the Air Force cancelled the MX-774, kept the program alive internally on a shoestring budget. Convair invested the company's own money to solve "problems related to pressurized tanks, separation of the warhead (or reentry vehicle) from the missile airframe prior to reentering the atmosphere, and thrust-vector steering" [Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 69].

[251] Even within the long-range, surface-to-surface missile category (which was ranked close to last in priority), ballistic missiles took a backseat to aerodynamic ones. The budget allocations for the fiscal years 1951 through 1954 reveal the little money ballistic-missile research received: Atlas received $26.2 million, while the Snark and the Navaho, another winged ground-launched winged cruise missile, got a total of $450 million [Steven Anthony Pomeroy, "Echoes That Never Were: American Mobile Intercontinental Ballistic Missiles, 1956-1983," Auburn University Dissertation, 7 August 2006, 28-29].

[252] Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 9.

[253] The Soviet Union tested their first thermonuclear bomb in August 1953.

realizing what this meant for the ICBM."[254] A lighter warhead meant an ICBM could be designed with a much lower gross weight, thus reducing the thrust requirements to a manageable level. Moreover, the higher yield of a thermonuclear warhead meant that the accuracy requirements could also be significantly relaxed.[255]

Trevor Gardner also recognized what the H-bomb test meant for ICBM development. He saw an opportunity to revitalize the Air Force's ICBM program when the Eisenhower administration, determined to reduce defense expenditures, created the Guided Missiles Study Group under the Armed Forces Policy Council. Eisenhower gave the group a charter to recommend ways to cut more from the Air Force's missile program, but after becoming aware of the H-bomb test results, the group cast aside its original mandate to suggest cost reductions and instead recommended a massive increase in missile R&D.

Seizing the opportunity, Gardner put together the Air Force Strategic Missiles Evaluation Committee, a sub-committee that would become known as the Teapot Committee. Gardner needed a group of eminent scientists to validate the feasibility of the ICBM, giving him ammunition to convince the authorities in the Air Force and the Department of Defense to launch a crash program to create an ICBM.[256] Gardner stacked the deck in his favor, appointing people to the committee whom he knew would give him the answer he wanted.[257] For

[254] Walter J. Boyne, "The Man Who Built the Missiles," *Air Force Magazine*, October 2000, 84.
[255] The first fission bomb test released the same amount of energy as approximately 20,000 tons of TNT. In contrast, the first thermonuclear ("hydrogen") bomb test released the same amount of energy as approximately 10,000,000 tons of TNT. The largest nuclear weapon ever tested, the "Tsar Bomba," produced an estimated yield of approximately 50 megatons, although a bomb that size was never produced as an operational weapon.
[256] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 220.
[257] Ibid. Dr. von Neumann volunteered to chair the committee. In addition to von Neumann, other members of the committee included Professor Clark Millikan, Cal Tech; Professor Charles Lauritsen, Cal Tech; Dr. Louis Dunn, Cal Tech; Dr. Hendrik Bode, Bell Tel Labs; Dr. Allen Puckett, Hughes Aircraft Company; Dr. George Kistiakowsky, Harvard; Professor J. B. Wiesner, MIT; Mr. Lawrence Hyland, Bendix Aviation; Dr. Simon Ramo, R-W Corp; and

example, Gardner appointed Dr. Simon Ramo and Dr. Dean Wooldridge, founders of Ramo-Wooldridge Corporation, later awarded the prime contract to provide "overall systems engineering and technical direction" for the Atlas program. Hence, Ramo and Wooldridge benefited from a favorable recommendation to pursue the technology.[258]

The Teapot Committee did not disappoint—they delivered a report that was all that Gardner wanted and a great deal more. The committee, which included some of the most respected figures in American science, not only validated the feasibility of the project, but said that the Air Force needed to conduct a "radical reorganization" to produce the missile.[259] The Committee said it was possible to build an operational ICBM in five to six years if the Air Force gave it overriding priority. The committee noted that "resistance within the Air Force to the ICBM could endanger the fledgling program, and publically recommended that the ICBM research and development effort be entrusted to a new management team."[260]

Having obtained scientific validation which, in Gardner's words, "those narrow-gauged bastards in the Pentagon couldn't back away from," the Undersecretary immediately moved to convince Air Force senior leaders to create a separate organization and proceed with a crash

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Dr. Dean Wooldridge, R-W Corp. [Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 9]. Later, Gardner would form a permanent Atlas (later ICBM) Scientific Advisory Committee. Seven of the original Teapot members stayed on and nine new members were added, including Norris Bradbury, director of the Los Alamos Laboratory, and Charles Lindbergh, the hero of the first transatlantic flight to Paris in 1927. Lindbergh had been declared a pariah by President Roosevelt for his isolationist and anti-Semitic agitation on the eve of the Second World War, but was resurrected by Secretary of the Air Force Harold Talbott who after the war awarded him a reserve rank of brigadier general [See *Fiery Peace*, p. 223].

[258] Although this appears as an obvious conflict of interest as Ramo and Wooldridge would profit from overseeing the Atlas program, Ramo would later claim that he had no idea that Gardner had a great deal more in mind for him and his business partner [Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 210].

[259] Ibid, 215.

[260] George A. Reed, "U.S. Defense Policy, U.S. Air Force Doctrine and Strategic Nuclear Weapon Systems, 1958-1964: The Case of the Minuteman ICBM," Duke University Dissertation, 1986, 35.

ICBM program.[261] In March 1954, Gardner met with Secretary of the Air Force Harold Talbott and General Nathan Twining, the Air Force chief of staff. Gardner proposed doubling the Air Force's fiscal year 1955 Atlas budget. He also proposed a separate organization within the Air Research and Development Command, headed by a major general whose sole responsibility would be to lead the ICBM program. Gardner recommended a crash development program to deliver two launch sites and four operational missiles by 1958, leading to the creation of twenty launch sites with a stockpile of 100 missiles by June 1960. Talbott and Twining were favorably predisposed to the idea, but referred the proposal to the Air Force Council, the senior uniformed corporate management review body of the Air Force.[262]

Talbott and Twining's favorable reaction to Gardner's proposal was not reflected in the vast majority of senior Air Force officers. General LeMay, one of the "narrow-gauged bastards" that Gardner had in mind when he made the comment, vociferously opposed building ICBMs because it would divert funds from bomber production. Taking a skeptical attitude, LeMay predicted that the Atlas would turn out to be an extravagant boondoggle and never perform as anticipated.[263] He argued that missiles would gain a "satisfactory state of reliability [only after]

[261] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 220. Trevor Gardner's personality traits did not endear him to very many senior Air Force generals. "Gardner did not hesitate to tell some important man that what he was doing 'isn't worth a good goddam.' And he once snapped, 'Shut up Tommy!' at Lieutenant General Thomas Power during a meeting in a room filled with other bestarred men. ... Like encounters led much of the senior Air Force leadership to detest Gardner" [Ibid, 197].

[262] "In 1951 General Hoyt S. Vandenberg, then chief of staff, formed the Air Force Council, which continues relatively unchanged today. It is the senior uniformed corporate management review body of the Air Force Board Structure." Although the great preponderance of decision-making takes place outside the Board Structure (i.e., by the formal, hierarchical organizations), the Board Structure decides "key issues and major decisions" [Gerald E. Cooke and Raymond C. Preston, Jr., "The Air Force Decision Process," *Air University Review*, January-February 1975, available at http://www.airpower.au.af.mil/airchronicles/aureview/1975/jan-feb/cooke.html].

[263] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 223.

long and bitter experience in the field."[264] The catch 22, of course, was that he consistently listed long-range missiles last among his SAC funding priorities, which meant that they would never be fielded and never have the opportunity to gain the "long and bitter experience in the field" that LeMay demanded. During one briefing covering the technical capabilities of ICBMs, LeMay asked Schriever, "What is the biggest warhead you can put on that missile?" "One Megaton," answered Schriever. "When you can put something on that missile bigger than a f***ing firecracker, come and see me," LeMay retorted.[265]

LeMay was not alone in his opposition to the development of the ICBM, a disruptive weapon system that threatened to replace the service's core instrument of war, whose primacy was enshrined in Air Force policy and strategy documents. General Thomas Power, LeMay's deputy at SAC who would later replace LeMay as SAC commander when LeMay moved up to become vice chief of staff, "pointed out that missiles would have to attain a high degree of accuracy and reliability before they could replace or supplement manned aircraft units."[266] He further noted: "Regardless of the missile program, it is the opinion of this headquarters that the continued advance in the art of manned flight to high altitudes and long ranges should be at all times a priority objective of the Air Force's development program."[267]

The bomber subculture's reaction to the emergence of ICBM technology was typical of any incumbent facing a disruptive threat; they reacted to ICBMs, a threat to their beloved

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[264] Quoted in Matthew Brzezinski, *Red Moon Rising: Sputnik and the Hidden Rivalries That Ignited the Space Age* (New York, NY: Henry Holt and Company, 2007), 81.
[265] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 413.
[266] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 507.
[267] Ibid. General LeMay chose Power to lead the firebombing of Tokyo. Power circled over the burning inferno of a city for nearly a half an hour watching it burn. General Power, like LeMay, was wedded to the manned bomber through his wartime experience.

weapon system, the manned bomber, by trying to disparage the capability of missiles. For example, General Clarence Irvine, a bomber pilot who served as deputy chief of staff, material, voiced his opposition to "a great downgrading of our manned bomber force" in favor of "romantic and exotic" missiles that he was "not prepared to stake the existence of the nation on."[268] After it became apparent that ICBMs were gaining momentum, bomber generals tried to claim ICBMs were best used in conjunction with bombers. They insisted ICBMs would supplement and/or complement the existing bomber force rather than replace it and argued that both systems were essential. Colonel James Tipton, an officer in the Air Force's plans directorate, wrote, "In most respects … missile systems are complementary and not competitive."[269] Likewise, LeMay insisted that missiles would, at best, serve only as "political and psychological weapons" and as "penetration aids" to manned bombers.[270]

LeMay and Power were unwavering in their insistence that manned nuclear bombers should take priority over ICBMs. In 1956, LeMay told Congress, "*We believe that in the future the situation will remain the same as it has in the past*, and that is a bomber force well-equipped, determined, well-trained, will penetrate any defense system that can be devised" (emphasis added).[271] Year after year, LeMay and Power submitted priority lists for SAC that ranked the manned nuclear bomber and enabling technologies such as KC-135 tankers at the

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[268] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership: 1945-1982* (Maxwell Air Force Base, AL: Air University Press, 1998), 84.
[269] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 511.
[270] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 121.
[271] George A. Reed, "U.S. Defense Policy, U.S. Air Force Doctrine and Strategic Nuclear Weapon Systems, 1958-1964: The Case of the Minuteman ICBM," Duke University Dissertation, 1986, 20. Interestingly, a 1950 House Armed Service Committee Report observed, "All advocates of every theory of American security turn back to the experiences of World War II for historical examples— for illustrations—to prove the soundness of their own arguments" [Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership: 1945-1982* (Maxwell Air Force Base, AL: Air University Press, 1998), 1]. LeMay was still reaching back to his World War II experience more than a decade later.

top of SAC's priority list while they kept ICBMs at the bottom. They did this well after General White's 1954 guidance that the Air Force's top priority going forward would be the ICBM. For example, SAC's 1956 priority list ranked B-52s first and weapon system 110A (a new supersonic bomber that was supposed to be chemically powered, a concept LeMay embraced only after his prized nuclear-powered bomber experienced technical difficulties) second.[272] LeMay ranked Atlas sixth on his list. Year after year, General White discarded LeMay's input and placed ICBMs back at the top of the Air Force priority list.[273]

In 1961, when the new Secretary of Defense Robert McNamara said, "I think the evidence points to a declining emphasis on [manned nuclear bombers]," LeMay and the other bomber absolutists vehemently protested.[274] LeMay said, "I seek weapon systems that I think can do the best job and afford the nation the most protection. In military thinking I am a conservative. I believe we shouldn't discard a proven, reliable weapon system or concept unless we have something that is able to replace it and do a better job. In short, I believe in having protection along with progress."[275] He convinced then Secretary of the Air Force Eugene Zuckert to adamantly fight for the Mach-3 XB-70 Valkyrie, LeMay's dream bomber. Zuckert told Congress that the reliability of missiles had not been proven and cautioned against becoming

[272] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 510. Weapon system 110A never left the drawing board; it was supposed to deliver a bomb with supersonic speed using a chemical engine, but the design was too large and too complicated to be feasible. The huge chemical load to fuel the engine would have resulted in a takeoff weight of 700,000 pounds.
[273] Thomas White, "USAF's Top Ten Priorities," *Air Force Magazine*, September 1960, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1960/September%201960/0960priorities.aspx.
[274] John T. Correll, "How the Air Force Got the ICBM," *Air Force Magazine*, July 2005, available at http://www.airforce-magazine.com/MagazineArchive/Pages/2005/July%202005/0705icbm.aspx.
[275] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 504.

over-dependent on them. Shortly after leaving office, on reflection, Zuckert admitted he had made a mistake backing LeMay.[276]

Despite how unpopular the idea of adopting ICBMs was among the senior Air Force elite, Gardner remained unrelenting in his battle against entrenched interests that favored the manned bomber, and he found an ally in General White when he pitched his idea for a crash ICBM program to the Air Force Council. White chaired the Air Force Council, and unlike the bomber absolutists led by LeMay, saw the need to push technologies and expand the Air Force's vision.[277] White recognized the merit in Gardner's proposal and took it upon himself to shepherd the Air Force into a new era. In May 1954, with the approval of his boss General Twining, White ordered that Project Atlas be given the Air Force's highest R&D priority. To emphasize how strongly he felt, he ordered the acceleration of the Atlas "to the maximum extent the technology would allow."[278]

In November 1954, White directed that achieving initial operating capability was the immediate objective of the ICBM program. Thus, the ICBM's top priority now included production as well as R&D.[279] The battle over the development of ICBMs did not end, however, with White's pronouncement. Resistance, led by General LeMay, intensified.

White and LeMay were not friends.[280] LeMay was supposed to come to Washington as vice chief of staff, serve under General Vandenberg as the heir apparent, and then step up to

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[276] George M. Watson, Jr., *The Office of the Secretary of the Air Force 1947-1965* (Washington, DC: Center for Air Force History, 1993), 43.
[277] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership: 1945-1982* (Maxwell Air Force Base, AL: Air University Press, 1998), 80.
[278] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 106.
[279] Ibid, 121.
[280] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 98.

the Air Force's top spot. But Vandenberg retired early due to illness, thus spoiling the succession plan. General Twining was an "accidental" chief. He was set to retire as a Lieutenant General, but when Muir Fairchild, Vandenberg's deputy, died unexpectedly of a heart attack, Twining filled his position.[281] When Vandenberg also suffered health issues, Twining moved up to the top spot. Twining unexpectedly hired White as his vice chief instead of LeMay. White served as Twining's vice from 1953 to 1957, and was then selected chief over LeMay. Newspapers hailed his surprising selection over LeMay as the fourth United States Air Force chief of staff, a position he would serve in until his retirement in 1961, as the "dark horse choice."[282] Undoubtedly, LeMay having to wait in line to be chief for nearly a decade did not contribute to good relations between White and LeMay.

In 1957, White selected LeMay to serve as his vice. White told confidants he thought LeMay would complement him the way that opposites do. "His experience, background, and probably his personality were quite different than mine. I knew it might be tough, but if it worked, it would be terrific for the Air Force," White explained. "There were times that I think General White really wondered if he had made a wise move in bringing General LeMay in," another senior officer remembered.[283] The reality was that LeMay had already spent nine years as the commander of SAC and had few other job options. Because he had been promoted at lightning speed during the war, LeMay had plenty of years left before he had to retire, so it is

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[281] Phillip S. Meilinger, *Airmen and Air Theory: A Review of the Sources* (Maxwell AFB, AL: Air University Press, 2010), 58.
[282] Jim G. Luca, "Son of Methodist Bishop Dark Horse Choice to be Next Air Force Chief," newspaper clipping in General Thomas White's collection at the Air Force Historical Agency (Maxwell AFB, AL) archives, 19 August 1957.
[283] General White did not have the operational credibility of Twining. It was partly for this reason that he brought LeMay to Washington as his vice chief of staff [Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 80-81].

not surprising that White chose to make LeMay his vice because he would have either had to force LeMay out or bring him inside the fold.[284]

As White points out, he and LeMay had fundamentally different backgrounds, personalities, and talents. In contrast to LeMay, who had few social skills and was not necessarily thought of as a deep thinker, White was brilliant, a true renaissance man.[285] A scholar fluent in seven languages—Chinese, Italian, Portuguese, French, Russian, Greek, Spanish, and English—White had served a short stint as a bomber commander in the Pacific war, but he spent most of his career in attaché positions around the globe.[286] From 1948 until 1950, White gained important political exposure, serving as director of legislative liaison for the Secretary of the Air Force. He was made for the position and quickly showcased his political and diplomatic talents. Secretary of the Air Force Eugene Zuckert recalled that White "was a sharp contrast to the usual World War II Air Force general. He was a deep and thoughtful individual. He impressed me more than any officer I had ever met. When he got that [first] job

[284] LeMay pinned on Major General in March 1944 at the age of thirty-seven, the youngest general in the entire U.S. Army. LeMay climbed from major to major general in four years. After the war LeMay became the youngest four-star general in US history since Ulysses S. Grant. Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 56. White, perhaps recognizing he did not have the political power to sideline LeMay, decided there was wisdom in the adage: "Keep your friends close. Keep your enemies closer." As Vice Chief, LeMay reported to White. Before being appointed Vice Chief, LeMay, as the commander of SAC, a "specified command," was his own boss.

[285] "At age, 18 White was the youngest person ever to graduate from West Point. … Colleagues described him as intellectual, aloof, polished, patient, articulate, well read, humane, gracious, imaginative, and of the highest integrity" [Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 65-66]. In contrast, LeMay's biography describes him as "dark, brooding, and forbidding. He rarely smiled, he spoke even less, and when he did, his few words seemed to come out in a snarl. Women seated next to him at dinner said he could sit through the entire meal and not utter a single syllable. Surly, tactless, and with a lifeless, moist cigar constantly locked between his teeth" [Warren Kozak, *LeMay: The Life and Wars of General Curtis LeMay* (Washington, DC: Regnery Publishing, 2009), ix].

[286] While stationed in Brazil as a military attaché, White, an internationally recognized ichthyologist, spent much of his time exploring jungle rivers. The Brazilians named two fish that he discovered after him—*cynolebias whitei* and *brycon whitei*. The English particularly liked White because he married the daughter of a British lieutenant general at a ceremony in Cairo, Egypt.

[legislative liaison to Congress], it became obvious that this man was a man of superior qualifications in an area where the Air Force was very, very poor."[287]

When White retired, an editorial observed, "It is both interesting and germane that General White never was a combat hero and that the qualities that made him 'just what the Air Force needed' when he became chief of staff four years ago are not those usually attributed to combat heroes. White has been described as 'a thoroughgoing professional and a global intellectual, a military and civilian thinker.'"[288] A former aide remembered "his grasp of overall strategy and his ability to sort of look out beyond today's world and see what might be important in the future is what really set him apart."[289]

White's efforts to shepherd the Air Force into a new era required more than issuing a directive to move ICBMs to the top of the service's priority list. Even in a hierarchical organization like the military, senior leaders cannot simply order an organization to innovate. Furthermore, from a strategic perspective, White needed to manage the transition carefully. In the 1950s, the Air Force was at a crossroads between two necessities—maintaining forces in being (i.e., the manned nuclear bomber, which had been designated as the principal instrument for achieving national objectives in the immediate present) and the necessity of adopting the ICBM to match the Soviet threat (i.e., the imperative of meeting a future need).[290]

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[287] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 66.
[288] Claude Witze, "Just What the Air Force Needed," *Air Force Magazine*, July 1961, 105.
[289] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 80.
[290] Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 13.

White's challenge was complicated by the fact that he also managed the Air Force's transition from propeller to jet aircraft. The soaring complexities of manned aircraft production at the start of the jet age contributed to mounting unit costs. An Air Force historian notes:

> The cost of weapons in a weapons system has been very great in terms of money and complexity … This cost has increased ten-fold from 1945 to 1955. … In aircraft gas turbines the number of parts has increased from 9,000 in 1946 to 20,000 in 1957. Of precious engineering hours, 17,000 were required to produce a fighter aircraft in 1940, and 1,400,000 in 1955.[291]

The Air Force, not unnaturally, reacted to rising costs by re-programming funds away from the debated missile area into its valued jet aircraft programs.[292]

President Dwight Eisenhower's insistence on delivering a balanced budget further squeezed defense spending, and the Air Force reacted by further cutting non-aircraft programs.[293] As a result, even though White ordered the Atlas program to proceed to the maximum extent the technology would allow, the corresponding funding to make that happen did not materialize as fast as he desired.[294]

Rather than deny the difficulties that he faced leading change, General White first acknowledged the bias in support of manned aircraft, the sustaining status quo, and against the unmanned weapon, the disruptive alternative, and then attacked it head on. White stated, "To

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[291] Stephen B. Johnson, *The United States Air Force and the Culture of Innovation* (Washington, DC: Air Force History and Museums Program, 2002), 11. Emphasizing the increasing complexity associated with the pursuing sustaining innovation to the manned aircraft fleet, Gardner wrote in 1956, "During the past two years, we have had to face the problem of learning to fly and fight at four times the speeds of World War II, and at altitudes so high there is literally no air left. This involves new problems in aerodynamics, electronics and power plants, problems not just four times as complicated as those of World War II, but more like 40 times as complicated [Trevor Gardner, "Must Our Air Force Be Second Best?" *Look*, 1 May 1956, 80].
[292] Stephen B. Johnson, *The United States Air Force and the Culture of Innovation* (Washington, DC: Air Force History and Museums Program, 2002), 11.
[293] *Time Magazine* observed, "The missile stands just about where the airplane stood after World War I—when military planes had to compete for the taxpayer dollar with the cavalry horse" ["ARMED FORCES: The Bird & the Watcher," *Life Magazine*, 1 April 1957, available at http://www.time.com/time/magazine/article/0,9171,867552-1,00.html].
[294] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 106.

say there is not a deeply ingrained prejudice in favor of aircraft among flyers would be a stupid statement for one to make. Of course there is."[295] In May 1954, he lectured the Air Staff, "Ballistic missiles are here to stay—you need to realize that and get on with it."[296]

In June 1954, Gardner, with White's blessing, selected Bernard Schriever to command the Western Development Division (WDD), the independent organization created within the Air Force to manage and build America's ICBM arsenal.[297] In that capacity, Schriever enjoyed considerable latitude of authority. In fact, Schriever accepted the position provided that he could run the show "without any goddamn nitpicking from those sons-of-bitches at the Pentagon."[298] Setting up the WDD was critical because, in a separate organization, Schriever could ensure funding for the ICBM program was appropriated independent of other Air Force requirements. Additionally, he was granted contracting authority so he did not have to go through higher headquarters for permission.

Setting up the WDD essentially cut the "bomber mafia" out of decision authority over missiles, preventing them from reprogramming money away from missiles to fund bombers. The WDD was nominally part of the Air Research and Development Command (ARDC), which allowed Schriever to access the command's resources and expertise, but Gardner ensured Schriever's chain of command flowed directly through the senior Air Force leadership rather than through the ARDC commander. That decision turned out to be critically important; otherwise, Schriever would have faced a steeper uphill battle. LeMay had maneuvered his

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[295] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 504.
[296] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 106.
[297] Major General Osmond J. Ritland remembers that Air Force leaders opposed the missile program because it detracted from aircraft development. "I think the only people that supported the [missile] program," he said, "'were those that were assigned to it" [Ibid, 107].
[298] Thomas P. Hughes, *Rescuing Prometheus* (New York, NY: Vintage Books, 1998), 103.

protégé Thomas Power into command of ARDC precisely because he wanted to keep the research and development organization out of the hands of technological visionary types like Schriever.

The differences between Schriever and Power in terms of background and experience mirrored those between White and LeMay. Though Schriever had flown bombers, like White, his career had taken him away from the cockpit. In Schriever's case, he went to graduate school, earned an engineering degree, and then entered the research and development field. His experience away from the cockpit, like General White's experience, made him less wedded to the manned bomber and therefore more willing to cannibalize the iconic weapon. Power, on the other hand, personified the operational Air Force par excellence.[299] He was the only senior World War II-generation general who had neither a civilian nor a military education beyond high school.[300] "As an operator, Power naturally tended to view the Air Force world in conventional terms," writes Sheehan.[301] Power understood virtually nothing of the nature of the task Schriever faced.[302]

Power objected when he received the Headquarters Air Force message directing the creation of the WDD, yet he had to comply. Sheehan describes Power's reaction:

> He was carrying out the directive because it was an order, but he didn't like it, Power said. The whole arrangement was unfair. He was being instructed to create a separate ICBM organization out on the West Coast run by a general officer who was to have complete authority over every detail of the program. Yet the directive also made Power responsible for the ultimate outcome. In short, he was to be held responsible for what

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[299] Ibid.
[300] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 81-2.
[301] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 251.
[302] Ibid, 251.

> he could not control. (His objection here was understandable, given the justly venerated military principle that there can be no responsibility without command.)[303]

Although Power's objection was understandable, for supporters of ICBMs it served as a brilliant counter to LeMay's maneuver.[304] It gave Power, to use a colloquial expression, "skin in the game." Power's fourth star depended on the program's success because the directive made him ultimately responsible while at the same time limiting his authority to internally obstruct progress or to divert R&D funds.

In 1955, Gardner orchestrated a change in administrative procedures that further removed control of the missile program from "bomber mafia" obstructionists. He put together a committee under Hyde Gillette, the Air Force Deputy for Budget, who devised procedures that made WDD solely responsible for planning, programming, and directing ICBM development.[305] The Gillette Procedures eliminated thirteen Air Force organizations from the ballistic-missile-approval chain and reduced the number of reviewing agencies from 38 to 10. "Gone was the old months-long functional review process, in which any one of numerous offices could demand changes, forcing the entire plan to be redone and the review process restarted."[306] Following implementation of the Gillette Procedures, the WDD answered to the newly created Air Force Ballistic Missiles Committee, a body chaired by the Secretary of the Air Force. Members of the committee included the secretary's principal assistants and the assistant chief of staff for guided missiles. The chain of command for the ICBM program was now vertical, from WDD to the Air Force BMC straight to the OSD Ballistic Missile Committee; as

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303 Ibid.
304 Ibid.
305 Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 120.
306 Marsha Kwolek and Grant Hammond, "The USAF and Ballistic Missile Development: A Case Study in Transformation," unpublished working draft, 21 September 2005, 31.

a result, a myriad of DoD and Air Force organizations was no longer able to alter the program via piecemeal changes.[307] The Gillette Procedures effectively circumvented established Air Force and Defense Department practices that had previously produced bottlenecks.[308]

Previous to the establishment of the WDD, the Air Force procurement bureaucracy treated missiles no differently than any other weapon system. In fact, the Air Force even followed a practice of designating guided missiles as "experimental bombers." The Atlas, for example, was given the designation XB-65. Air Force Letter 136-3, released in September 1952, codified this approach; it emphatically asserted that "missiles were not revolutionary weapons" and they did not deserve special treatment.[309] Interestingly, Lieutenant General Earle Partridge, Power's predecessor at ARDC, was one of the few dissenters to this policy. He wrote General White a memorandum blasting the guidance in Air Force Letter 136-3 and advocating a major organizational shift. He urged White to consider the fundamental changes that missiles were about to produce.

> He asked how anyone could not consider a weapon revolutionary that promised to transport hydrogen bombs over a distance of more than 5,000 miles. … Partridge called for entirely new assumptions requiring "a realignment of our thinking." He warned that failure to recognize this truth would produce two divergent schools of thought with the Air Force. "One of these schools will be small but vigorous and will insist that the job can be done by the guided missile. The other group, representing the old fogies, will continue to insist that we adhere to the tried and proven aircraft." Partridge cited as evidence past splits that had separated flying and seaborne elements in the Navy and ground and air in the Army.[310]

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[307] Ibid.
[308] John Clayton Lonnquest, "The Face of Atlas: General Bernard Schriever and the Development of the Atlas Intercontinental Ballistic Missile, 1951-1960," Duke University Dissertation, 1996, 198.
[309] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 90.
[310] Ibid, 90-91.

White started to write a long response, but instead informed Partridge, "I tore up reply to you. You have some very cogent points."[311]

In September 1955, efforts to develop and adopt the ICBM received a boost when President Dwight Eisenhower issued National Security Council (NSC) Action No. 1433, giving the development of ICBMs the nation's "highest priority above all others."[312] The presidential directive alleged "gravest repercussions on the national security and on the cohesion of the free world" if the Soviet Union prevailed in the race to develop ICBMs.[313] As discussed more in the next section, the issuance of NSC Action No. 1433 gives the misleading impression that the Eisenhower administration helped lead the adoption of the ICBM. Eisenhower, more interested in restraining defense spending rather than championing an expensive new weapon, had to be cajoled into signing the directive.

In 1956, White lectured Air War College students on stagnation in thought within the Air Force: "We see too few examples of really creative, logical, far-sighted thinking in the Air Force these days. It seems to me that our people are merely trying to find new ways of saying the same old things about air power without considering whether they need changing to meet new situations and without considering the need for new approaches to new problems."[314]

An important fiscal milestone also occurred in 1956. White managed to stem the service's practice of reprogramming money to protect its manned aircraft programs. White steadfastly insisted that missiles should enjoy the Air Force's top R&D priority, only to have his

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[311] Letter, Lt Gen T. D. White, DCS/O, to Lt Gen Earl E. Patridge, Commander, ARDC, 2 February 1953, Air Force Historical Research Agency (Maxwell AFB, AL) archives.
[312] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 300.
[313] Ibid, 299.
[314] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 80.

intent frustrated by budget maneuvers. R&D expenditures for missiles, however, finally achieved parity with those for manned aircraft.[315]

In June 1957, General White put together a board of senior officers chaired by Lieutenant General Donald Putt, the deputy chief of staff for development, to review ICBM development and to assess the prospects for smooth missile integration into the service. Putt reported that there was a lack of Air Force interest and understanding by most top-level officers when it came to missiles.[316]

In September 1957, two months after taking over as chief, General White called his top commanders together at a conference and scolded them for their negative attitude towards missiles. He noted that some were as wed to the airplane as the cavalrymen were to the horse. "The senior Air Force officer's dedication to the airplane is deeply ingrained, and rightly so but we must never permit this to result in a battleship attitude. We cannot afford to ignore the basic precept that all truths change with time," White told his top generals.[317] White insisted that his top commanders remain flexible and ready to adopt superior technologies.[318] Importantly, he noted that money limitations would not permit both the acquisition of ICBMs and indefinite funding to maintain the current inventory of manned nuclear bombers. He warned that ever-improving Soviet antiaircraft missile capability would continue to reduce the manned nuclear bomber's effectiveness. "With the advent of the guided missile, the US Air force is in a critical era of its existence. It is essential that we all pull together in the effort to

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[315] Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 9.
[316] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 99.
[317] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 514.
[318] Ibid.

properly utilize this family of new weapon systems for the defense of our Nation," emphasized White.[319]

White also outlined a new missile credo at the conference. The purpose was to offer a new institutional vision on missile development and employment. To establish a sense of urgency, White declared, "According to current roles and missions the Air Force has the greatest need for such weapons." Next, like any good diplomat, White sugarcoated the unpalatable message he delivered in the bottom line of the credo. To offset the harsh reality of the predictable displacement of manned nuclear aircraft by ICBMs, White consoled his audience, "Missiles, as they are perfected, will supplement and complement the manned aircraft. However, to preserve the required capability and flexibility of operations, it is essential that the Air Force maintain a significant force of manned aircraft during the foreseeable future."[320] The bottom line, however, of the credo stated: "As rapidly as missiles become operationally suitable, they *will* be phased into units either to *completely or partially substitute* for manned aircraft according to military requirement" (emphasis added).[321]

The month after White held his commander's conference, the Soviets successfully launched Sputnik, the world's first artificial satellite, atop the R-7, the world's first ICBM.[322] The United States would counter by conducting the first successful launch of the Atlas on

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[319] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 515.
[320] Ibid.
[321] Ibid.
[322] The Sputnik launch occurred on October 4, 1957. The day prior, General White had testified before Congress predicting that the Soviets might very well beat the United States in the missile race. White was consistent in relaying that message to Congress, even when that view conflicted with his civilian boss, Secretary of the Air Force Quarles. For example, White sharply warned that the Soviet Union was not only "maintaining scientific and technological advances at a faster rate" than the United States, but was also "beating us at our own game—production." White made these remarks days after Quarles had assured a Texas audience that any recent Soviet technological developments were of minimal importance [George M. Watson, Jr., *The Office of the Secretary of the Air Force 1947-1965* (Washington, DC: Center for Air Force History, 1993), 115].

December 17, 1957.[323] It would take another two years, though, before the United States deployed three SM-65D Atlas missiles on open launch pads at Vandenberg Air Force Base on the California coast, providing the country with an "emergency" ICBM capability in September 1959. The U.S. Air Force would eventually field eleven operational Atlas squadrons.

Technical challenges due to the nature of the Atlas's liquid-fuel design limited the missile's attractiveness. In the early 1960s, a series of explosions occurred when crews attempted to load liquid propellant into an Atlas and a Titan I test vehicle.[324] The explosions destroyed several facilities at Vandenberg AFB. With the reliability of the Atlas hovering around fifty percent, congressional inquiries and sharp media coverage ensued. Schriever maintained his equanimity, philosophizing, "when at the leading edge of technology and plowing new ground … if you do not have failure every now and then, you are not taking enough risks. We must move ahead with the courage to take calculated risks. Otherwise we will find ourselves equipped with obsolete weapon systems that invite national disaster."[325]

The challenges of maintaining a force of liquid-fueled rockets, along with interservice competition from the Navy's Polaris program (see next section), spurred the Air Force to develop the Minuteman, a second-generation solid-propellant missile—smaller in size, lighter in weight, less complex, and significantly less expensive. The missile eliminated many of the storage and handling problems that plagued the Atlas, and it cost less than one-fourth as much

[323] The U.S. Navy tried to launch a satellite on December 6, 1957 using a Vanguard rocket, but it exploded on launch. The United States put a satellite called Explorer 1 into space on January 31, 1958. The launch missile was a Jupiter C. The first successful Atlas launch was preceded by two failures.
[324] See, for example, the following news articles: "Titan Missile Explodes in Underground Silo," *New York Times*, 4 December, 1960, 5. "New Atlas Blows Up on PAD in California," *New York Times*, 8 June 1961, 18. "Atlas Is Destroyed; Debris Hits Town," *New York Times*, 11 August 1962, 3. "Titan I Explosion is 'Rotten Luck,'" *New York Times*, 28 May 1962, 18.
[325] Marsha Kwolek and Grant Hammond, "The USAF and Ballistic Missile Development: A Case Study in Transformation," unpublished working draft, 21 September 2005, 23.

as what it would have cost to produce a liquid-fuel missile of the same size. Moreover, rather than requiring extensive lead time before launch, the Minuteman could be sprung immediately from its silo.

The development of the Minuteman proceeded at such a fast pace that it was pressed into service on October 29, 1962, during the Cuban missile crisis.[326] Minuteman was originally scheduled for a 1964 fielding date, but the first eight tests went so well that the remaining ten were cancelled. By way of comparison, three of the first five Atlas flight tests failed. Minuteman was fielded at a furious pace; within five years from its first test flight in 1961, more than one thousand Minuteman missiles stood poised in their silos ready to strike the Soviet Union at a moment's notice.[327]

ASSESSING EXPLANATORY VALUE

The Insufficiency of Posen, Rosen, and Coté

Although insightful, the three standard political science theories put forth by Rosen, Posen, and Coté's provide incomplete explanations for the U.S Air Force's development and adoption of the ICBM. Rosen contends innovation takes place at a generational pace, proceeding "only as fast as young officers rise to the top."[328] He says advocates of change find protectors and patrons, experiment doctrinally, and slowly climb the promotional ladder,

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326 The first Minuteman test flight, a complete success, took place on 1 February 1961, and by 24 October 1962 the first 10 missiles were on alert outside Malmstrom Air Force Base, Montana.
327 By July 1964, twelve squadrons with 50 Minuteman missiles apiece were operational, forming the bedrock of the nation's strategic deterrence.
328 Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 105.

contending with rivals for control over the direction of a military service.[329] Although Rosen's theory may accurately describe other cases, it does not match the historical record when it comes to the speed at which the U.S. Air Force developed and adopted ICBMs.[330] Rosen's theory predicts gradual change, yet the U.S. Air Force undertook a crash program to build and field the weapon. It took less than five years from when the U.S. Air Force got serious about developing an ICBM to when the service deployed its first operational missiles. It took a mere seven years from when ICBMs achieved an initial operating capability to when the weapon system reached its peak quantity (see Figure 8).

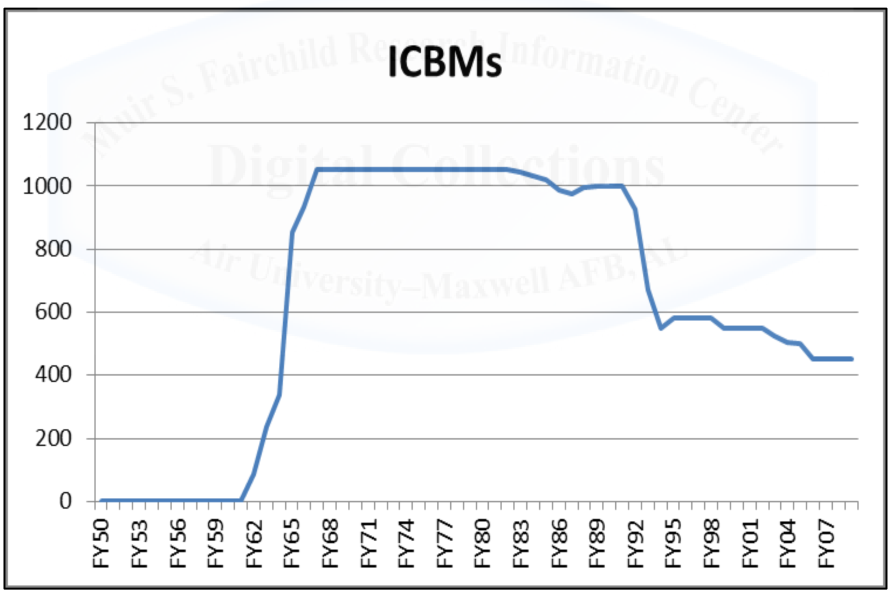

FIGURE 8 – The ICBM Life-Cycle Curve[331]

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[329] Ibid, 7.

[330] Perhaps this is why Rosen includes a discussion of ICBMs in the section of his book that covers "purely technological innovations" instead of covering it under the section that addresses doctrinal innovation [Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 5]. This allows him to attribute missile development and adoption to the "business of military research and development (R&E) communities" [p. 185] and thus avoid having to explain it with his intraservice innovation model that predicts generational change.

[331] Ibid.

Not only does Rosen get the pace of innovation wrong, he also confuses cause and effect. The Air Force did not adopt ICBMs *because* there had been a change in who held power within the service. The transition from a bomber- to a fighter-pilot-dominated Air Force occurred almost two decades *after* ICBMs reached their peak quantity.[332] Moreover, the adoption of ICBMs did not occur because fighter pilots, the rising ruling class, were more receptive to ICBMs than bomber pilots.[333] Fighter pilots did not "experiment doctrinally" with ICBMs and then rise through the ranks as Rosen's theory predicts. Rather, the adoption of ICBMs led to a change in the institutional leadership of the U.S. Air Force. In other words, the adoption of ICBMs helped cause bomber pilots to lose their grip on power, not vice versa.[334] Certainly, an internal political struggle occurred within the Air Force, but it was not resolved via "control over promotion paths" as Rosen's theory suggests.[335] Bomber absolutists actually consolidated their grip on power throughout the 1950s, the critical period when the Air Force wrestled with whether or not to adopt ICBMs, which contradicts what Rosen's model suggests should have occurred. By October 1961, at the start of the growth phase of the ICBM's technological lifecycle, one historian notes: "*all* major operational commanders and the vast majority of the Air Staff leadership [positions were filled with] ardent bomber generals—most of them SAC absolutists. SAC's methods became Air Force methods (emphasis added.)"[336]

[332] The transition of power from bomber to fighter pilots within the U.S. Air Force did not occur until 1982 when General Charles Gabriel became the first fighter pilot to become chief of staff. Previous to Gabriel's selection as chief, an unbroken string of ten bomber pilots filled the top leadership position.
[333] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 7.
[334] To emphasize, the sequence of events is important because it strikes at the heart of the validity of Rosen's theory.
[335] As per the prediction of this study, the ICBM faced stiffening internal resistance.
[336] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 89.

Indeed, LeMay, the *capo di tutti capi* of the "bomber mafia," succeeded White as chief of the service.[337]

Barry Posen's theory also does not adequately explain why the U.S. Air Force adopted ICBMs. Posen suggests the armed services are unlikely to innovate on their own, and as a result, change comes through energetic civilian intervention.[338] Although Posen does not address ICBMs in his writings, President Eisenhower's National Security Council (NSC) Action No. 1433, which gave the development of ICBMs the nation's "highest priority above all others," could be cited as evidence that civilian intervention forced the U.S. Air Force to adopt ICBMs against its institutional wishes.[339] The problem with crediting Eisenhower's decree with forcing the U.S. Air Force to adopt ICBMs is that the directive was signed on September 13, 1955, more than a year after General Thomas White, then Air Force vice chief of staff, placed the ICBM atop the service's research and development (R&D) priority list.

In fact, Eisenhower had to be politically cajoled into signing NSC Action No. 1433. He approved the document at the behest of missile enthusiasts in the Air Force, but he did not share their sense of urgency concerning ICBM development.[340] Eisenhower believed that "economic vitality and diplomatic alliances backed up by a credible military strength—'security with solvency'—provided the best formula for containment."[341] Wanting to avoid what he called "an unbearable security burden leading to economic disaster," Eisenhower made the

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337 The Italian phrase *capo di tutti capi* (boss of all bosses) refers to the leader of the mafia.
338 Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 44-45.
339 Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 299-300.
340 Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 132.
341 Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership: 1945-1982* (Maxwell Air Force Base, AL: Air University Press, 1998), 66. Eisenhower's priority was to constrain defense spending in order to achieve a balanced budget.

manned nuclear bomber the centerpiece of his administration's New Look defense policy because it gave the country, to use a popular slogan, "more bang for the buck."[342] His aim was to lower the defense budget, or at least constrain military spending, and deliver a balanced budget. Moreover, Eisenhower believed the country's strategic force-in-being was superior to that of the Soviets.[343] Consequently, he had little interest in funding an expensive, new weapons program.

To get Eisenhower to sign the directive NSC Action No. 1433, Trevor Gardner convinced two influential Senators—Henry Jackson, the Chairman of the Atomic Energy Subcommittee on Military Applications, and Clinton Anderson, the Chairman of the Joint Committee on Atomic Energy—to pressure the President. Jackson and Anderson wrote to Eisenhower in June 1955, criticizing the "peacetime footing" under which the administration was proceeding with the development of ICBM technology.[344] Jackson and Andersen urged him to order a crash program to field ICBMs. Eisenhower, a Republican, would have suffered political fallout if he ignored the request since it came from two of the most powerful Democratic Senators in the country.

The senators were also successful in whipping up a ground swell of public support, which influenced Eisenhower's decision to sign the Air Force-generated request to make ICBMs the nation's top development priority. During one National Security Council meeting, the President, acknowledging pressure from the public, referred to "the mass of letters and telegrams which he was receiving from people all over the country, insisting that the program

342 Samuel P. Huntington, *The Common Defense* (New York, NY: Columbia University Press, 1961), 66.
343 Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 132.
344 Ibid, 134.

in the U.S. to achieve a ballistic missile should be placed in the hands of one single individual and that everything should be done to hurry the project to completion."[345]

The following exchange between Jackson and Gardner during congressional hearings examining airpower highlights how a cabal of mostly Democratic Senators struggled against and finally succeeded in getting the administration to make ICBM's the nation's highest development priority:

> Senator JACKSON. Now what reason can you give for the delay on the decision to give the ICBM an overall priority as distinguished from a priority solely within the Air Force?
>
> Mr. GARDNER. I don't know of any reason for the delay that I could explain, Senator. … technological changes are coming faster than our current decision-making machinery in Government is able to work … something has to be done about [it].
>
> Senator JACKSON. Some of the committees of Congress had to push this a little bit, didn't they?
>
> Mr. GARDNER. They certainly did, Senator.
>
> Senator JACKSON. You are familiar with some of that. We won't go into details here now. But it was not until certain steps were taken by another committee that an overall priority was given by the President; is that correct?
>
> Mr. GARDNER. That is right.[346]

Eisenhower, more interested in restraining defense spending rather than championing an expensive new weapon, was also boxed into signing NSC Action No. 1433 by the 1955 report of the Technological Capabilities Panel, commonly known as the Killian Committee after its chair James Killian, the president of the Massachusetts Institute of Technology. The Killian

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[345] "Memorandum of Discussion at the 268th Meeting of the National Security Council, Camp David, Maryland, December 1, 1955," *Foreign Relations of the United States, 1955–1957 Volume XIX, National Security Policy, Document 45*, available at http://history.state.gov/historicaldocuments/frus1955-57v19/d45.

[346] Senate, "Study of Airpower," Hearing Before the Subcommittee on the Air Force of the Committee on Armed Services, Eighty-Fourth Congress, Second Session, 14 June 1956, Part XIII, 1118.

Committee declared that the nation faced growing vulnerability from a surprise Soviet missile attack.[347]

Less than three months after Eisenhower was politically pressured into assigning the development of ICBMs the "highest priority above all others," the president modified that decision, effectively diluting it.[348] On December 1, 1955, President Eisenhower, acting on the advice of his Secretary of Defense, Charles Erwin Wilson, approved NSC 1484, a National Security Council recommendation that assigned "joint" national priority to the ICBM and several Intermediate Range Ballistic Missile (IRBM) programs.[349]

Wilson had adamantly opposed assigning the ICBM the "highest priority above all others" via presidential directive. He remarked, "The assignment of an absolute overriding priority for one specific weapon system, such as the ICBM, … [was] not necessarily the most effective way to utilize national resources, particularly since no one form of weapon can be considered sufficient to meet the needs of national security."[350] He claimed ICBMs, by virtue of General White's pronouncement, already enjoyed "highest priority" status within the Department of Defense. Wilson's statement, however, was disingenuous; the State Department's representative on the NSC Planning Board pointed out, "About 180 other projects … are said to enjoy this same rating. Moreover, it is understood that, even with this rating, the

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[347] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 120. Gardner had a hand in the committee's creation, and he even gave its members their first briefing, which would become the Committee's message to the president [Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York, NY: Random House, 2009), 273].

[348] President Eisenhower was not necessarily opposed to building ICBMs. However, he ranked fiscal conservatism above the need to spend massive amounts of money in order to expedite the production of ICBMs.

[349] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 146. "Robert Bowie [the State Department's representative on the NSC Planning Board] cautioned that it was not enough. In a paper to the acting Secretary of State (Hoover), he pointed out that even though the ICBM was DoD's highest priority, 180 other projects held the same rating" [Ibid].

[350] Ibid, 135.

ICBM program has been seriously delayed by the existing procedures for clearance and approval. It has been estimated that as much as a year or more could be saved by cutting through some of this procedural routine."[351]

NSC 1484 provided political cover for the Eisenhower administration, suggesting it was doing everything possible to advance missile research while at the same time effectively diluting the "priority" status it bestowed on missiles in order to keep defense spending low.[352] Priority for all meant priority for none. Gardner commented, "The Air Force ICBM program, which had received highest Air Force priority … in May 1954, was now given highest national priority by the President. However, by mid-1956, this decision had become diluted, so that, despite the terminological contradiction, this highest priority granted to the Air Force ICBM was being shared with the Air Force IRBM, the Army IRBM, and several other related and supporting programs."[353] Gardner continued, "Moreover, in spite of continuing disturbing information concerning the [Soviet Union], Secretary Wilson inexplicably issued instructions which tended to slow down the entire ballistic missile program."[354] Favoring a "poor man's approach" to missile development, the Eisenhower administration reduced the Air Force's 1957 "minimum budget request" from $20 billion to $16.5 billion, delayed the target date to achieve an initial operating capability for the Atlas, and reduced the number of missiles the Air Force had

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[351] Robert Bowie, "Memorandum From the Director of the Policy Planning Staff (Bowie) to the Acting Secretary of State," *Foreign Relations of the United States, 1955–1957: National Security Policy: Volume XIX Document 33*, 7 September 1955, available at http://history.state.gov/historicaldocuments/frus1955-57v19/d33.
[352] In fact, that is exactly the argument Eisenhower used to deflect criticism after the Soviets launched Sputnik. The President said, "Positive orders have been issued several times that the guided missile program has priority over any other in the Defense Department [but] there are limits to what you can do in research and development." [Robert Hotz, "Gardner Quits, Starts USAF R&D Fight," *Aviation Week*, 13 February 1956, 28.
[353] Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 11.
[354] Ibid.

planned to acquire.[355] When the Senate debated whether to increase the Air Force's fiscal year 1957 budget by $800 million, Secretary Wilson criticized those efforts as "phony." His comments incensed a large number of senators, leading many to demand his resignation.[356]

Donald Quarles, who was appointed Secretary of the Air Force (SECAF) in 1955, was pressured by the administration to support across-the-board defense spending cuts. Interestingly, before he became SECAF, Quarles was an outspoken advocate of spending more on ICBM development. When he served as the Assistant Secretary of Defense for research and development, Quarles told the Aviation Writers Association at a Washington, DC press conference that "incessant and expensive research in airpower and missile power is essential," warning his audience that the nation was falling behind the Soviets.[357] After his appointment as SECAF, Quarles fell in line with the administration's view and repeatedly clashed with Gardner and White as well as the aforementioned Senators over their attempts to get more funding for ICBM development. In one incident, Senator Symington accused Quarles of lying to Congress

[355] George M. Watson, Jr., *The Office of the Secretary of the Air Force 1947-1965* (Washington, DC: Center for Air Force History, 1993), 155. In December 1955, the Air Force first proposed that the ICBM initial operational capability consist of one wing with three bases (2 Atlas and 1 Titan), each deploying 40 missiles and 20 launchers. Ten missiles would be operational on 1 April 1959 and the entire force of 120 ICBMs by 1 January 1960. On 29 March 1957, however, President Eisenhower approved a new ICBM plan that called for only 80 missiles (40 Atlas and 40 Titan). One launch complex of three launchers and six missiles would achieve operational status by March 1959, while the entire force of 80 ICBMs would be operationally deployed by March 1961 ["Weapons of Mass Destruction: Early Developments," http://www.globalsecurity.org/wmd/systems/icbm-early.htm].

[356] George M. Watson, Jr., *The Office of the Secretary of the Air Force 1947-1965* (Washington, DC: Center for Air Force History, 1993), 158. "Even Republicans such as former Chairman of the Senate Appropriations Committee, Styles Bridges of New Hampshire, called Wilson's pronouncement an 'unwarranted slur on all senators.' Democrats were incensed. Senator George Smathers of Florida stated that he could not recall when another government official had managed so often to insult not only his coworkers, but members of Congress as well. … Senator Dennis Chavez of New Mexico reminded Wilson that he was not running the General Motors Corporation but working for the public. 'Every time he holds a conference,' the senator remarked, 'as the proverbial saying goes, he puts his foot in his mouth'" [Ibid, 158-159] [See also Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 169]. "Wilson's charge that the Senate debate was politically motivated brought a heated exchange with Democratic Senator Henry Jackson. During the exchange, Wilson told a story about a "mama whale" saying to her calf that "it is only when you are blowing that you are liable to be harpooned." Senator Jackson retorted, "Mr. Secretary, I think the public knows who has been doing a lot of blowing" [Ibid].

[357] Claude Witze, "Change in Quarles' Thinking Seen in Emphasis on Skilled Personnel," *Aviation Week*, 13 February 1956, 29.

after his testimony conflicted with that of his field commanders.[358] Quarles staunchly defended the administration's position that the 1957 budget was austere but adequate, but "admitted that the Soviet Union was already flight-testing a ballistic missile with a range of 1,500 miles, while no comparable weapon had yet left the drawing boards in the United States."[359]

Gardner, fed up and frustrated with the Eisenhower administration's lack of support and sense of urgency when it came to ICBM development, resigned in protest. Citing a "difference of opinion [with the Eisenhower administration] about the importance and scope of the Air Force research and development program and guided missiles program in relation to the threat," Gardner told the press he quit his job so he could speak "the truth" to the public. He accused the administration of obscuring the truth in an "avalanche" of propaganda and misinformation.[360] Gardner proceeded to deliver scathing criticism of the administration's defense policies in a series of articles, interviews, and speeches.[361] In one article written shortly after he resigned, Gardner decried the "lack of candor of certain members of the Administration in describing the state of the [ICBM] program to the nation."[362] He warned, "With every tick of the clock, the Soviet Union is moving closer to the capability of knocking this country out. … Russia is outpacing our country in ballistic missiles … There is no time for 'business as usual.'"[363]

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[358] George M. Watson, Jr., *The Office of the Secretary of the Air Force 1947-1965* (Washington, DC: Center for Air Force History, 1993), 158.
[359] Ibid, 155.
[360] Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 4.
[361] George M. Watson, Jr., *The Office of the Secretary of the Air Force 1947-1965* (Washington, DC: Center for Air Force History, 1993), 160. For example, Gardner published articles critical of the administration in *Air Power Historian* and *Look* and gave interviews to multiple news organizations, including *Time*.
[362] Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 4.
[363] Trevor Gardner, "Must Our Air Force Be Second Best?" *Look*, 1 May 1956, 77.

Senator Stuart Symington, another powerful Democrat who had helped Jackson and Anderson ratchet up political pressure on Eisenhower to give ICBM R&D more funding, agreed with Gardner's assessment.[364] In a wire to fellow Senator and Democrat Richard Russell, Symington wrote, "We continue to learn of the missile accomplishments of the possible enemy. For fiscal reasons this Government, in turn, continues to cut back and slow down its own missile program. I have been warning about this growing danger for a long time, because the future of the U.S. may well be at stake. Therefore, I respectfully but earnestly request that as chairman of the Armed Services Committee, you arrange for complete hearings in this matter before the committee. Only in this way can the American people learn the truth. Putting it mildly, they have not been getting that truth."[365]

In summary, civilian intervention, through the actions of Gardner, the cabal of senators, and others, played an important role in the adoption of the ICBM. Nonetheless, Posen's model alone does not tell the whole story. Posen insists military organizations seldom innovate on their own initiative, and thus innovation requires civilians to impose change on those in uniform. But in this case, General White helped lead the charge for change against significant civilian resistance, which conflicts with Posen's theory. Moreover, giving credit to civilians for the adoption of ICBMs neglects General Bernard Schriever's role as an agent of change.

Lastly, Owen Coté's interservice competition model, like the other two, also insufficiently explains the rapid growth of ICBMs. Concern over losing its monopoly on the nuclear delivery mission helped push the U.S. Air Force to adopt ICBMs, but interservice

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[364] Symington served as the first Secretary of the Air Force from 1947 to 1950, but resigned in protest over what he thought was insufficient funding for the U.S. Air Force.

[365] Lynne L. Daniels, "Statements of Prominent Americans on the Opening of the Space Age: A Chronology of Select Statements October 4, 1957 to November 13, 1958," National Aeronautics and Space Administration Historical Note No. 21, 15 July 1963, 2.

competition was not the primary driver. If interservice competition was the overriding factor in the Air Force's decision to embrace the ICBM, then one would expect the decision to occur when interservice competition was at a highpoint. Yet the opposite occurred. The Air Force cancelled its nascent ICBM program in 1947, shortly before interservice rivalry reached crisis proportions. The service essentially abandoned ICBM research for the next seven years, exactly when post-war interservice rivalry reached a peak. The Air Force revived its ICBM program when interservice conflict was at a low point. Indeed, General White moved ICBMs from the bottom of the Air Force's priority list to the top after Secretary of Defense Louis Johnson awarded the service exclusivity over long-range missiles. One of Johnson's successors, however, would subsequently renege on that decision.

After World War II, the services engaged in a bitter feud over roles and missions as they sought to carve out their position in a post-war, consolidated Defense Department.[366] "The angriest interservice fight...since the Billy Mitchell days" culminated in a 1949 incident known as the "Revolt of the Admirals."[367] The debate that caused the "Revolt" had been building for

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[366] The National Security Act of 1947 merged the Department of War and the Department of the Navy into the National Military Establishment, headed by the Secretary of Defense. The act was amended in 1949 to subordinate the service secretaries to the Secretary of Defense. At the same time, the National Military Establishment was renamed the Department of Defense. Not only did the uncertainty associated with consolidating into a single Department of Defense fuel interservice rivalry after the war, but the emergence of a newly independent service, the United States Air Force, also added another dimension to interservice competition. See Samuel P. Huntington, "Interservice Competition and the Political Roles of the Armed Services," *The American Political Science Review,* Vol. 55, No. 1, March 1961. Huntington argues, "Interservice rivalry was the child of unification. Both reflected the unity and complexity of modern war, and without the one, the other would never have come into existence" [p. 40-41].

[367] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 127. Billy Mitchell, assistant chief of the air service, feuded with the Navy during the interwar years over the effectiveness and role of airpower versus capital ships, such as super dreadnoughts, enormous steam-propelled battleships. Mitchell's outspoken airpower advocacy irked the Navy. "Mitchell considered the dreadnought his enemy. Based on the evidence of the war, he felt that no naval fleet could survive a battle if a land-based air force could reach it. Mitchell spoke out in favor of airpower for coastal defense often, angering the Navy. And the press, sensing readership in stories of inter-service rivalries, encouraged Mitchell by printing his speeches and articles. Finally, in February 1921, the Navy could not ignore Mitchell anymore. Testifying before the House subcommittee on aviation, Mitchell stated that 1000 bomber aircraft could be built and operated for the cost of one

years but came to a head with the cancellation of the *USS United States*, the first of the Navy's planned large fleet of "supercarriers." Testifying before Congress, a group of senior Navy leaders protested the cancellation of the *United States*, taking the opportunity to criticize the Air Force's B-36 Peacemaker and publically question its combat effectiveness. "With all the impressive might of a carrier strike, the U.S. Navy last week brought its rebellion into the open. Risking their careers, the Navy's highest-ranking officers ranged themselves in flat opposition to the declared policies of the U.S. Congress, the Secretary of Defense, the Joint Chiefs of Staff and the President. … The outburst went far deeper than interservice bickering. Its weight made the shabby machinations and underhanded skullduggery that had preceded it seem inconsequential," *Time Magazine* reported.[368] Many of those who testified, including Chief of Naval Operations Louis Denfeld as well as Secretary of the Navy John Sullivan, were either fired or forced to resign.

The post-war squabbles over roles and missions extended to who would own and control ballistic-missile technology, although the argument was somewhat curious because none of the services actually made any moves beyond rhetoric. Nevertheless, all the services sought to establish placeholders, giving them the right to develop the technology as they saw fit in the future. The result was a series of interservice negotiations, strategic positioning, and less-than-fruitful reviews.[369]

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dreadnought and that his airplanes could sink a battleship." In July 1921, Mitchell orchestrated an exercise in which his aircraft sank three ships—-a destroyer, an armored light cruiser, and a dreadnought—obtained from the Germans from the peace agreement that ended World War I. All three were successfully sunk. For a summary of this episode, see Pamela Feltus, "Billy Mitchell Sinks the Ships," available at http://www.centennialofflight.gov/essay/Air_Power/mitchell_tests/AP14.htm.

[368] "ARMED FORCES: Revolt of the Admirals," *Time Magazine*, 17 October 1949, available at http://www.time.com/time/magazine/article/0,9171,853921-1,00.html.

[369] For a discussion of these events, see the section titled "National Guided Missile Program" (p. 50-56) in Jacob Neufeld's *The Development of Ballistic Missiles in the United States Air Force 1945-1960*.

In May 1949, the Army sought to end the on-going quarrel over who would own and control ballistic missiles by making a "once and for all" stab at settling the issue.[370] The Army proposed to the Joint Chiefs of Staff (JCS) that it be given responsibility for all surface-launched missiles. As part of the plan, it recommended the Navy control ship-launched missiles and the Air Force be given responsibility for air-to-surface missiles.[371] The JCS deliberated for months and finally released guidance in the fall of 1949 that basically gave all the services the right to develop missiles. The chiefs failed, however, to address the question of who would control long-range surface-to-surface missiles. The Air Force interpreted this as a victory, reasoning that since it had the strategic bombardment mission, it was the logical choice to own long-range, surface-to-surface ballistic missiles.[372]

After more disagreement and ambiguity, the JCS reconsidered its previous pronouncement and in March 1950 released a plan, approved by Secretary of Defense Johnson, assigning the Air Force "formal and exclusive responsibility for developing long-range strategic missiles and short-range tactical missiles."[373] Contrary to the JCS guidance, the Army and Navy continued to sponsor missile "studies and designs;" nevertheless, the other two services essentially deferred to the Air Force in terms of long-range ballistic-missile development for the next five years. It was during this five-year period that the Air Force revived its ICBM program

[370] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 53.
[371] Ibid.
[372] Ibid.
[373] Ibid.

and General White made his pivotal 1954 decision to move ICBMs to the top of the Air Force priority list.[374]

The Army did not develop a competing missile program until well after the Air Force had embarked on its crash ICBM development program. Dr. Wernher von Braun, the German scientist who had designed the V-2, immigrated to the United States after the war as part of U.S. efforts to recruit German rocket scientists. As head of the U.S. Army's rocket program, he petitioned the Army's chief of ordnance for permission to develop a missile with a range of 1,000 miles in 1953, but the Army showed little interest in building the weapon. Von Braun's long-range rocket project would have continued to languish if not for the Eisenhower administration's decision to assign "joint" priority between the ICBM and the Intermediate Range Ballistic Missile (IRBM). As a result, in the fall of 1955, all three services—the Army, Navy, and Air Force—petitioned to develop IRBMs. Secretary of Defense Wilson directed the Air Force pursue the Thor IRBM and the Army and Navy to work together to develop the Jupiter IRBM. His idea was to pit the two missiles against each other, thereby spurring interservice competition. The Air Force began developing the Thor in January 1956, and the Army stood up its Ballistic Missile Agency at Redstone Arsenal in February 1956.

The Navy, corralled into the partnership with the Army by Secretary Wilson, was never really interested in developing the Jupiter, a rocket that relied on volatile liquid fuel. Liquid fuel, a technology incompatible with maritime operations, posed a huge safety risk for ships; and in September 1956, the Navy pulled out of the Jupiter project in order to develop Polaris, a solid-fueled submarine-launched ballistic missile (SLBM).

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[374] The 1951 revival occurred primarily on paper as the U.S. Air Force commissioned more studies, but few experiments.

In November 1956, Secretary Wilson gave the Air Force sole responsibility for operating surface-launched missiles with a range in excess of 200 miles. Living on borrowed time, the Army hoped early development success would convince the Secretary of Defense to change his mind. In October 1957, after news of the Soviet launch of Sputnik, President Eisenhower ordered both Thor and Jupiter into production. But the Army was unable to reverse Secretary Wilson's November 1956 ruling barring it from operating long-range missiles. "As a result, although the Army won the right to build Jupiter, it did so as a subcontractor to the Air Force. Much to the Army's chagrin, the Air Force assumed control of the Jupiter program in early 1958."[375]

Secretary Wilson's belated attempt to induce competition may have retarded rather than accelerated the development and adoption of long-range, surface-to-surface missiles. Opinion is divided over whether it induced the Air Force to buckle down and speed up production or if it caused unnecessary delays. Dr. Alvin Weinberg, director of Oak Ridge lab, came down decidedly in the latter camp when he said, "Interservice competition in making of missiles is for the birds."[376] Likewise, General Bernard Schriever thought developing the IRBM, especially devoting resources to multiple programs spread across all three services, significantly interfered with ICBM development.[377] The competing programs placed a premium on already-scarce scientific talent and test facilities and caused unnecessary duplication and cost. Similarly, Dr. C. C. Furnas, Assistant Secretary of Defense for Research and Development from December 1955 until February 1957, remarked, "We finally decided that breaking the space

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[375] "Jupiter IRBM Development History," www.globalsecurity.org/wmd/systems/jupiter.htm.
[376] C. C. Furnas, "Why Did U.S. Lose the Race? Critics Speak Up," *Life Magazine*, 21 October 1957, 20.
[377] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960* (Washington, DC: Office of Air Force History, 1990), 115.

barrier would be an easier task than breaking the interservice barriers. If the job was to get done in a hurry, it had to go to a single branch of service."[378]

Interservice competition was not the proximate cause for the Air Force's decision to adopt the ICBM. Secretary Wilson had to nudge the Army and Navy into competing with the Air Force over IRBM production. The two services entered the fray after the Air Force had already committed to developing the Atlas. Coté, however, rightly points out that the Navy's development of the Polaris in 1958 spurred the Air Force to pursue and accelerate production of the Minuteman, its own solid-fuel rocket, but this occurred well after General White's 1954 decision to give ICBM development the service's top priority. Indeed, the Air Force had committed to developing its first generation ICBM years before the Polaris was even a twinkle in the eye of the Navy leadership.

The New, Cross-Disciplinary Framework Adds Value

Historical evidence from this case suggests the new, cross-disciplinary framework adds explanatory power. Answering the set of questions posed in the "Research Approach" section of Chapter 1, the following discussion summarizes that evidence.[379]

First, do changes in a state's security situation and interservice competition, the two factors identified in doctrinal innovation literature as drivers of innovation, sufficiently explain

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[378] C. C. Furnas, "Why Did U.S. Lose the Race? Critics Speak Up," *Life Magazine*, 21 October 1957, 20. In his *Airpower Historian* article, Trevor Gardner says it was not clear whether interservice competition over the IRBM accelerated or retarded missile development, but what was "perfectly clear" was the fact that Wilson's decision was costly and wasteful [see Trevor Gardner, "How We Fell Behind in Guided Missiles," *Air Power Historian*, Vol. 5, No. 1, January 1958, 11].

[379] The questions highlight key differences between Posen, Rosen, and Coté theories and the new, cross-disciplinary model proposed in this study.

when and why the U.S. military adopted the ICBM? Or, per this dissertation's central hypothesis, did the perceived attributes of the ICBM also weigh heavily in leaders' decisions?

The perceived attributes of the ICBM appear to have weighed heavily in its development and adoption, more so than changes in the nation's security situation and interservice competition. Germany's use of the V-2, a technological Hail Mary to reverse the course of World War II, improved two perceived attributes of missile technology: trialability and observability. The V-2's success piqued the interest of the United States and the Soviet Union, leading both nations to start experimental programs to develop an ICBM. Immediately after WWII, the U.S. Army Air Forces, which became the U.S. Air Force in 1947, initiated a program that would eventually evolve into the Atlas, America's first operational ICBM. But interest waned after it became clear the task of designing a missile large enough to carry a payload the size and weight of a Hiroshima-type nuclear bomb would be difficult. Moreover, experiments demonstrated abysmal missile accuracy and reliability. As a result, the service assessed that the manned nuclear bomber, a weapon that twice proved during WWII that it could reliably and accurately deliver nuclear payloads, offered a greater relative advantage than the ICBM. Bomber generals running the Air Force had just spent more money developing the B-29 than any other weapon in the history of warfare. Moreover, they had already signed a contract to procure the B-36 Peacemaker, a jet-powered Superfortress on steroids that represented the next generation of manned bombers. Faced with shrinking post-war budgets, it is no surprise the U.S. Air Force canceled its nascent ICBM program in 1947 and abandoned ICBM development for the next seven years. The Soviet Union, on the other hand, did not have a

fleet of manned nuclear bombers to compete with the new weapon, which helps explain why it pressed ahead full-bore with ICBM development despite technological challenges.

The development of the thermonuclear bomb, intended as a sustaining improvement in the payload carried by manned nuclear bombers, caused an abrupt shift in the relative advantage offered by ICBMs versus that of manned bombers. The technological advance helped sway Trevor Gardner, Bernard Schriever, and most importantly Thomas White, who made the pivotal decision in May 1954 to elevate the ICBM to the top of the Air Force's R&D priority list and then steadfastly shepherded the disruptive weapon's adoption. White explained his decision to push the Air Force to adopt missiles in a 1958 article. He wrote, "The Air Force embarked on the intermediate- and long-range missile programs because the combat potentialities of missiles offered certain advantages in comparison with manned systems."[380]

White's background made him more willing to discount organizational costs associated with adopting the ICBM. Unlike LeMay, White's professional success and identity were not linked to the manned nuclear bomber. Spending little time in the "traditional" Air Force, White spent most of his career posted to diplomatic and legislative affairs positions. He was not a war hero; indeed, his diary suggests he spent much of his short stint in the Pacific during the war fishing, one of his passions. White recognized that adopting the ICBM meant a diminished role for the manned nuclear bomber, yet he did so for broader reasons of national security rather than protect entrenched service interests. He remembers "telling the Air Staff on many occasions that the build-up in strategic missiles such as the Atlas, Titan, and Minuteman was

[380] Thomas D. White, "Air and Space are Indivisible," *Air Force Magazine*, March 1958, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1958/March%201958/0358indivisible.aspx].

not good for the *traditional* Air Force but it was vital for the nation" (emphasis added).[381] In contrast, LeMay wanted to conjoin the Air Force's future to the manned nuclear bomber; at one point, he advocated doing away with all conventional TNT ordnance in the Air Force's inventory and transitioning exclusively to nuclear bombs carried by manned bombers. LeMay, Power, and the rest of the bomber generals demanded "protection along with progress," while White was able to "to steer clear of cliques and cabals, and win a reputation for sheer performance."[382] Consequently, he was more willing to cannibalize the manned nuclear bomber fleet to realize the potential offered by the ICBM. Symbolically, in 1958, on the eve of the Atlas becoming operational, White ordered the creation of a Guided Missile Insignia, specifying that it could not include wings of any kind.[383] White made the tough, unpopular decision to adopt the ICBM, even though it irritated many men in Air Force blue, because he was convinced it was best for the United States and the long-range good of the USAF itself.[384]

The growing missile threat from the Soviet Union may have influenced White, but little evidence indicates the concern exerted more than background influence.[385] Stephen Rosen, one of the scholars who champion the idea that changes in a state's security situation drive innovation, acknowledges that military research and development decisions through the middle of the 1950s reveal a pattern of organizational behavior divorced from intelligence about

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381 Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: U.S. Government Printing Office, 1988), 190.

382 "ARMED FORCES: The Power For Now," *Time Magazine*, 25 November 1957, available at http://www.time.com/time/magazine/article/0,9171,891804-2,00.html.

383 George Mindling and Robert Bolton, *U.S. Air Force Tactical Missiles 1949-1969: The Pioneers* (Raleigh, NC: Lulu, 2008), 131. The badge was renamed the "Missileman Badge" in 1963. It was renamed again in 1979, becoming the "Missile Badge." The criteria for awarding the Guided Missile Insignia were published on May 23, 1958 in Air Force Regulation 35-5.

384 Claude Witze, "Just What the Air Force Needed," *Air Force Magazine*, July 1961, 108.

385 White served as a military attaché in Moscow. He, of all the generals in the Air Force, would have perhaps been the most qualified individual in the service to understand the intentions of the Soviet Union and the threat it posed.

enemy technology.[386] Citing declassified records, Rosen also admits decisions regarding the ICBM were made with surprisingly few intelligence inputs.[387]

In 1958, Bernard Schriever wrote: "Early in 1954 … the Air Force was able to begin a full-scale assault on the development of an intercontinental ballistic missile. This action was made possible largely because of the thermonuclear breakthrough in 1952-53. In other words, we were *energized by technology and not by intelligence data*" (emphasis added).[388]

The Soviet launch of Sputnik in 1957 generated intense public and congressional interest in speeding the development of missile development. Nevertheless, the event occurred more than three years after White's pivotal 1954 decision. Moreover, President Eisenhower, privy to intelligence on Soviet missile capability from U-2 spy flights, cautioned against over-reacting to the launch of Sputnik, although he did bow to public and congressional hysteria, ordering Thor and Jupiter, two IRBMs, into production. However, that directive may have slowed the fielding of the ICBM as it diverted resources from the Atlas program.

Interservice competition over long-range strategic nuclear missiles did not emerge until well after the U.S. Air Force had initiated a crash program to develop an ICBM. Army leaders, unenthusiastic about a weapon that did little to support ground operations, rebuffed a 1953 petition from Dr. Wernher Von Braun, the head of the Army's rocket program, to develop missiles with a range of 1,000 miles. At the time, the Army had little appetite to challenge a directive from the Secretary of Defense that prevented it from building missiles with a range that exceeded 200 miles. Von Braun's long-range rocket project would have remained a dream

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386 Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 187.
387 Ibid.
388 Bernard Schriever, "The Air Force's Ballistic Missile Program," *Air Force Magazine*, April 1958, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1958/April%201958/0458ballistic.aspx.

if not for the Eisenhower administration's decision to overturn the restriction and push the Army and Navy into partnering to build the Jupiter in an effort to foster interservice competition. As a result, the Army stood up its Ballistic Missile Agency at Redstone Arsenal in February 1956, years after White's pivotal decision. The Navy, corralled into the partnership with the Army at the behest of the Secretary of Defense, was never really interested in developing the Jupiter, a rocket that relied on volatile liquid fuel. Accordingly, in September 1956 the Navy pulled out of the Jupiter project in order to develop Polaris, a solid-fueled submarine-launched ballistic missile (SLBM). The Navy, like the Army, did not enter the fray for years after the Air Force had re-started its ICBM program.

Second, was interservice competition, as Coté alleges, overwhelmingly a function of "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services"?[389] *Or, did the perceived attributes of the ICBM also influence competitive and cooperative patterns of service behavior?*

Historical evidence suggests competitive and cooperative patterns of service behavior are not just a function of "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services"[390] In this case, the perceived attributes of the ICBM also played a role in whether and when interservice competition emerged.

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[389] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 351. See also p. 339-340.
[390] Ibid.

Coté contends President Eisenhower's use of the "remainder method" for budgeting and his "extremely laissez-faire" attitude about the defense budget provided an incentive among the services to poach each other's funding and compete over long-range ballistic missiles.[391] Historical evidence supports that claim. During Eisenhower's first term, defense department spending declined 20%, from $442.3 billion in 1953 to $356.2 billion in 1956.[392] President Eisenhower's management style not only encouraged the services to compete for their share of shrinking top-line funding, but his approval in December 1955 of NSC 1484, which assigned "joint" national priority to the ICBM and two IRBM programs, signaled a willingness to accommodate funding growth in programs more compatible with Army and Navy interests, thus providing an incentive to compete. Interservice competition ensued shortly thereafter, leading to innovation.

Nevertheless, interservice competition requires a perception that an attractive alternative exists. A decade earlier, innovation stagnated despite what Coté's theory suggests should have been ripe conditions. In the years after WWII, the services experienced sharp budget cuts. Furthermore, in 1947 President Harry Truman signed legislation that created the National Military Establishment (renamed the Department of Defense in 1949). The legislation consolidated previously separate service budgets. Under the old regime, the Army and Navy were separate departments. Under the new one, the services had the opportunity to compete for each other's slice of a consolidated defense department budget. According to Coté's theory, interservice competition leading to innovation should have resulted, but that did not

[391] The Bureau of the Budget estimated government revenues, subtracted non-discretionary government expenses, and gave the defense department the remainder. Eisenhower imposed annual budget ceilings on DoD to maintain a balanced overall federal budget. … with a budget ceiling and policy guidance firmly in place, Eisenhower adopted an extremely laissez-faire attitude about how the services chose to invest their funds …" [Ibid, 354-356].
[392] Source: Center for Defense Information.

happen. The services engaged in bitter battles, but innovation, at least in terms of long-range ballistic missiles, did not occur.[393] The Air Force retrenched, cancelling its nascent ICBM program and abandoning ICBM development for years. Similarly, the Army and Navy put their missile programs on the back burner. Years later, the Secretary of Defense was able to nudge the Army into competing with the Air Force, but that occurred only after the perceived attributes of missiles had evolved. Similarly, the Secretary of Defense was able to order the Navy into a half-hearted partnership with the Army, but the Navy abandoned it as soon as technological developments led to a more attractive alternative: the Polaris, a second-generation, solid-fuel missile. Moreover, the Air Force did not rush to embrace the Minuteman, its solid-fuel missile, just because of concerns over interservice competition. It recognized a solid-fuel missile offered significant advantages over a liquid-fuel one. In other words, factors other than "civilian management style" helped 'fuel' interservice competition. Coté admits as much: "Polaris and Minuteman quickly replaced the previous four liquid fuel missile programs at much less cost and with much more survivability."[394] That is to say, the perceived attributes of the innovation influenced service behavior.

In summary, the Navy chose not to pursue liquid-fueled ballistic missiles, even though the Air Force was pursuing the weapon, because the technology was not compatible with maritime operations. It wanted no part of liquid propellant aboard ships after several hair-raising test launches of captured German V-2's from the decks of one of its aircraft carriers. It waited to get into the nuclear game until after technology had advanced to the point where it

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[393] For example, see discussion earlier in this chapter on the "Revolt of the Admirals."
[394] Owen Reid" Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 27.

became feasible to place solid-fuel missiles on a submarine, something that offered a much higher relative advantage than storing highly-volatile and explosive liquid-fueled rockets on surface ships.

Third, is the pace of innovation binary? In other words, does it occur at one of two speeds: fast or slow? Or, does it tend to occur commensurate with the rate at which relative advantage evolves?

The U.S. Air Force adopted crash programs to develop the Atlas and the Minuteman. Similarly, the U.S. Navy also conducted a crash program to build the Polaris. Hence, the historical record seems to best match Barry Posen's assertion that innovation, when it occurs, happens at a fast pace. Nevertheless, the pace at which the Air Force and Navy adopted the ICBM is not incompatible with the new, cross-disciplinary framework proposed in this study. The development of the thermonuclear bomb abruptly shifted relative advantage in favor of the ICBM, which provided an incentive for its quick adoption. Moreover, the Navy did not pursue the Polaris and the Air Force did not pursue the Minuteman until after technological developments made their solid-fuel design more attractive. In other words, weapon system innovation appeared to proceed commensurate with the evolution of relative advantage.[395]

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[395] The ICBM appears an exception in terms of the pattern of its adoption. Unlike the helicopter, and unmanned aircraft (see the next two chapters), the ICBMs did not follow the route that Clayton Christensen suggests is common for disruptive innovations: first fulfilling peripheral roles and then graduating to core missions. Manned aircraft, although not covered in this study, followed a pattern similar to the helicopter and unmanned aircraft in their adoption.

Fourth, did civilians or military leaders drive weapon system innovation, or were both civilians and uniformed leaders influential?

General White, a uniformed officer, perhaps deserves the lion's share of the credit for shepherding the adoption of the ICBM, but he did not act alone. Civilians such as Trevor Gardner and the cabal of Democratic senators were indispensable instigators. Other military officers, notably General Schriever, also provided vital support.[396] Thus, both military officers and civilians were influential.

The next chapter continues exploring post-World War II airpower-related weapon system innovation, investigating the adoption of the helicopter.

[396] It is also worthwhile to note that both military and civilians leaders were resistant to adopting the ICBM. LeMay openly opposed the adoption of the ICBM, although to his credit, he eventually embraced them later in his career. President Eisenhower, more interested in balancing the budget than spending money on new weapons, had to be cajoled into signing NSC 1433 and immediately took steps to dilute the directive. Additionally, Eisenhower's Secretary of Defense, Charles Erwin Wilson, took actions that frustrated and slowed the U.S. Air Force's adoption of the ICBM.

CHAPTER 4

HELICOPTERS

"Since 1947 … the Army has been a dissatisfied customer, feeling that the Air Force has not fully discharged its obligations undertaken at the time of unification."[397]

— *General Maxwell D. Taylor, U.S. Army Chief of Staff*

This chapter investigates the U.S. Army's adoption of the helicopter. First, it presents a historical narrative discussing events and factors that stimulated the service to adopt the helicopter. Next, it compares the explanatory power of Owen Coté, Barry Posen, and Stephen Rosen's theories with that offered by the new, cross-disciplinary framework proposed in this study. The case reveals that the latter adds value.

HELICOPTER HISTORY

Ripe Conditions for the Adoption of the Helicopter

The U.S. Army has historically felt wronged by what it sees as an Air Force failure to prioritize close air support and other missions augmenting ground operations.[398] Embers of this smoldering conviction formed during World War I, but caught fire after the U.S. Air Force broke away from the Army in 1947. Stripped of its aircraft, the Army found itself dependent on the Air Force for its air support, but neglected. The U.S. Air Force pursued ever-more-perfected

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[397] Maxwell D. Taylor, *The Uncertain Trumpet* (Westport, CT: Greenwood Press, 1974), 168-170.
[398] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 165.

versions of its favored weapon, the strategic nuclear bomber, leading to increasing discontent within the Army and ripe conditions for the adoption of helicopters.

Early airpower theorists believed that airpower, if properly developed and applied, would transform modern warfare.[399] They emphatically rejected the prevailing view among senior Army leaders that airpower was simply a marginal adjunct to ground forces. For example, General John J. Pershing, commander of American Expeditionary Forces in WW I, thought the proper function of airpower was, in his words, "to drive off hostile airplanes and procure for the infantry and artillery information concerning the enemy's movements."[400]

The lack of vision and, at times, outright hostility towards aviation displayed by Pershing and other senior Army leaders drove airmen to develop their "autonomy triad" in the 1920s and 1930s. First, they claimed that a separate autonomous organization was required because only those who appreciate the full potential of airpower should be in charge of developing and managing it.[401] Second, airpower enthusiasts argued that air resources are most effective in combat as a centralized, autonomous strike force, not frittered away in support of multiple ground force units.[402] Finally, to justify independence, airmen developed a doctrine that prescribed a unique mission that only airpower could achieve: strategic bombing deep behind enemy lines.[403] They claimed wars could be won by destroying industrial and military targets

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[399] Sanford L. Weiner, "Evolution in the post-Cold War Air Force: Technology, Doctrine, and Bureaucratic politics" in *U.S. Military Innovation since the Cold War: Creation without Destruction*, Eds. Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman (New York, NY: Routledge, 2009), 101.
[400] John J. Pershing, *My Experiences in the World War, Volume II*, p. 337 cited in "Plans & Early Operations: January 1939 to August 1942," *The Army Air Forces in World War II*, Eds. W. F. Craven and J. L. Cate, available at http://www.ibiblio.org/hyperwar/AAF/I/AAF-I-2.html#fn75.
[401] Sanford L. Weiner, "Evolution in the post-Cold War Air Force: Technology, Doctrine, and Bureaucratic politics" in *U.S. Military Innovation since the Cold War: Creation without Destruction*, Eds. Harvey M. Sapolsky, Brendan Rittenhouse Green, and Benjamin H. Friedman (New York, NY: Routledge, 2009), 101.
[402] Ibid.
[403] Ibid.

deep within enemy-held territory while leaving an enemy's army and navy intact. Indeed, the deeper the target, the greater the impact of its destruction.[404] As a result, airpower enthusiasts proposed that long-range heavy bombers flying in large numbers and at high altitude should take a primary position in planning and funding rather than low-altitude fighters optimized for ground support.

The autonomy triad would spawn the foundational tenets of the U.S. Air Force; it is also the source of irreconcilable differences between the Air Force and Army leaders.[405] At its core, the disagreement centers on who should control airpower and how it should be used. Army doctrine insists "ground commanders on the spot" should exercise operational control over supporting air units, just like they do with artillery.[406] It emphasizes the use of airpower as an enabler of ground troops. In contrast, Air Force doctrine claims airpower is most effective when untethered from ground units.

In July 1943, airpower enthusiasts, seeking to codify that principle, crafted Field Manual (FM) 100-20 *Command and Employment of Air Power*, widely viewed as airpower's "declaration of independence." FM 100-20 declared in all capitalized letter: "LAND POWER AND AIR POWER ARE CO-EQUAL AND INTERDEPENDENT FORCES; NEITHER IS AN AUXILIARY OF THE OTHER." Furthermore, it proclaimed, "CONTROL OF AVAILABLE AIR POWER MUST BE CENTRALIZED AND COMMAND MUST BE EXERCISED THROUGH THE AIR FORCE COMMANDER."

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404 Kenneth P. Werrell, *Chasing the Silver Bullet* (Washington, DC: Smithsonian Books, 2003), 99-100. "Least effective, in the airmen's view, would be aerial attacks at or near the front. Targets there are difficult to neutralize for three reasons: deployed, dug-in, and camouflaged targets are hard to detect; they are difficult to destroy, requiring in most cases direct or very close hits; and the frontline is dangerous for aircraft, as it will be thick with antiaircraft defenses and friendly fire. For these reasons airmen shunned close air support operations" [Ibid].
405 Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 136.
406 Ibid. Marine Corps doctrine also insists ground commanders must exercise operational control over supporting air units,

Additionally, it mandated that a theater commander "WILL NOT ATTACH ARMY AIR FORCES TO UNITS OF THE GROUND FORCES UNDER HIS COMMAND."[407]

General George Marshall, the Army chief of staff at the time, signed the document, despite adamant opposition from Army Ground Forces commander General Lesley J. McNair.[408] McNair vociferously opposed making airpower coequal to ground power and was particularly angry that FM 100-20 made close air support the last of three priorities for the use of airpower. McNair alleged that the document was merely a subterfuge to further the goal of Air Force self-determination under the guise of lessons learned at Kasserine Pass, a battle during the North Africa campaign of World War II. He accused the Army Air Forces (AAFs) of being indifferent to the demands of ground forces and demonstrating ineptness in distinguishing friend from foe.[409] Ironically, he was killed by friendly fire when an AAF bomber dropped a bomb in his foxhole near Saint-Lô during the Battle of Normandy in 1944.

After the war, as part of negotiations to secure an independent Air Force, General Carl Spaatz, the chief of the Army Air Forces, promised General Dwight Eisenhower, the new Army chief of staff, that the Air Force would maintain a Tactical Air Command to supply the Army's

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[407] War Department Field Manual 100-20, "Command and Employment of Air Power," 21 July 1943, available at http://www.ibiblio.org/hyperwar/USA/ref/FM/FM100-20/index.html. FM 100-20 makes an exception for assigning air forces to ground forces when they are "operating independently or are isolated by distance or lack of communication" [Ibid].

[408] A 1942 executive order divided the Army into three autonomous forces: the Army Air Forces (AAF), Army Ground Forces, and the Services of Supply (which in 1943 became the Army Service Forces). Each of these forces had a commanding general who reported directly to the chief of staff of the United States Army. The Army Air Corps became the Army Air Forces.

[409] John P. Owens, "The Evolution of FM 100-20, Command and Employment of Air Power, (21 July 1943): The Foundation of Modern Airpower," U.S. Army Command and General Staff College Monograph, 2 Jun 1989, abstract. The Battle of the Kasserine Pass took place during the Tunisia Campaign of World War II in February of 1943. Airpower enthusiasts assert that the American army suffered significant casualties because air forces were parceled out among ground forces and not used effectively. Many aircraft remained idle while adjacent ground forces were being trounced.

airpower needs.[410] Despite Spaatz's promise, after being granted independence from the Army in 1947, the Air Force abandoned any pretense of adequately preparing to support ground troops. General Spaatz immediately gave priority to the "Strategic Air Force," a euphemism for strategic nuclear bombers, which he called "the backbone of our Air Force."[411]

The direction Spaatz took the Air Force should not have been a surprise. He simply continued the approach outlined decades earlier by the Air Corps Tactical School (ACTS), an influential strategy school where the roots of Army Air Corps doctrine were formulated during the interwar years. Spaatz's statement about the primacy of bombers exactly mirrors the central planning assumption made by a 1931 ACTS textbook: "Bombardment aviation, under the circumstances anticipated in a major war, is the basic arm of the Air Force."[412] Indeed, Spaatz was a graduate of the program.

Influenced by bomber "absolutists" like General Curtis LeMay, Spaatz's newly independent Air Force distanced itself technologically and doctrinally from the battlefield.[413] LeMay, who served a short post-war stint in a newly created headquarters position with a mandate to coordinate the service's R&D activities, would begin to funnel nearly all R&D funds into building bigger, faster, and higher-flying aircraft, which the Army perceived as not conducive to close air support. From an Army perspective, LeMay's actions violated the terms of agreement for Air Force independence. Aircraft that flew longer distances gave them the potential to fly only farther away from the front lines of a conventional battle, the place where

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410 Richard G. Davis, *The 31 Initiatives* (Washington, D.C.: Office of Air Force History, 1987), 9.
411 House, "Military Establishment Appropriation Bill for 1948: Hearing before the Subcommittee of the Committee on Appropriations," 80th Congress, 1st session, 1947, 600.
412 David E. Johnson, "Modern U.S. Civil-Military Relations: Wielding the Terrible Swift Sword," INSS McNair Paper 57, July 1997, 7.
413 Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 107.

the Army most wanted them. Moreover, the Air Force's focus on nuclear delivery necessarily meant it neglected conventional bombing. Simply stated, it is impossible to effectively perform "close" air support with nuclear bombs.

After taking over Strategic Air Command (SAC) in 1948, LeMay got the U.S. Air Force Senior Officer Board to declare that strategic bombing was the primary mission of the service and must be given the greatest consideration and priority.[414] LeMay wanted SAC to ditch the conventional mission altogether. He declared, "If you have to employ strategic air power against tactical targets, you are not getting the full use of the weapon."[415] The general proposed that the Air Force merge its strategic and tactical forces into a single offensive force and leave the Army to its own devices.[416] Although his proposal was not approved, LeMay presided over an organization that was increasingly ill equipped for conventional operations.

The gap between what the Army demanded and what the Air Force delivered in terms of airpower widened during the 1950s. In the midst of the Korean War, with soldiers dying from a perceived lack of air support, the Air Force began to develop a nuclear-powered strategic bomber—the WS-125A, also known as the Aircraft Nuclear Propulsion (ANP) program. The requirement for the WS-125A literally specified that the program should deliver the "maximum supersonic speed possible."[417] The very idea of a nuclear-powered bomber may seem absurd today, but nevertheless, it appeared as a promising, albeit ambitious, sustaining

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414 Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 307.
415 Ibid, 242-243.
416 Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 176. "This proposal died after encountering strong resistance from TAC's General Weyland" [Ibid].
417 Michael Brown, *Flying Blind* (Ithaca, NY: Cornell University Press, 1992), 201. "The origins of the nuclear-powered bomber program can be traced to 1946, when the AAF initiated a series of feasibility studies collectively known as the Nuclear Energy Propulsion for Aircraft (NEPA) project" [Ibid, 194].

innovation along a technological trajectory that was highly valued by the "bomber mafia." From an Army perspective, though, the nuclear-powered bomber program was utterly useless. Over Army protests, the Air Force consistently ranked the nuclear-powered bomber among its top development priorities, pouring more than $1 billion into the program over the next decade before it was finally cancelled by the Kennedy administration in 1961.[418]

Almost immediately after initiating the ANP program, it became readily apparent to Air Force planners that designing a practical airborne reactor was going to be difficult. In 1954, the Air Force conducted a program review to determine its options. The Air Force's worst-case scenario was that the ANP would grind to a halt and leave the service without a replacement for its most valued weapon system.[419] Even under the best of circumstances, the program was not going to produce any operational aircraft until the early 1960s. The "bomber mafia," increasingly threatened by the ICBM program which was projected to deliver operational missiles starting in the early 1960s (see Chapter 3), hedged its bets and pushed the Air Force to concurrently pursue a second advanced bomber program, a "chemical bomber," designated the WS-110A. The Air Force needed a fallback option as well as a near-term option to complement the ANP.[420] Like the ANP, the technical challenges of producing a practical "chemical bomber" proved insurmountable, and the program eventually evolved into the XB-70 Valkyrie (see Figure 9).

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[418] Ibid, 195.
[419] Ibid, 199.
[420] Ibid.

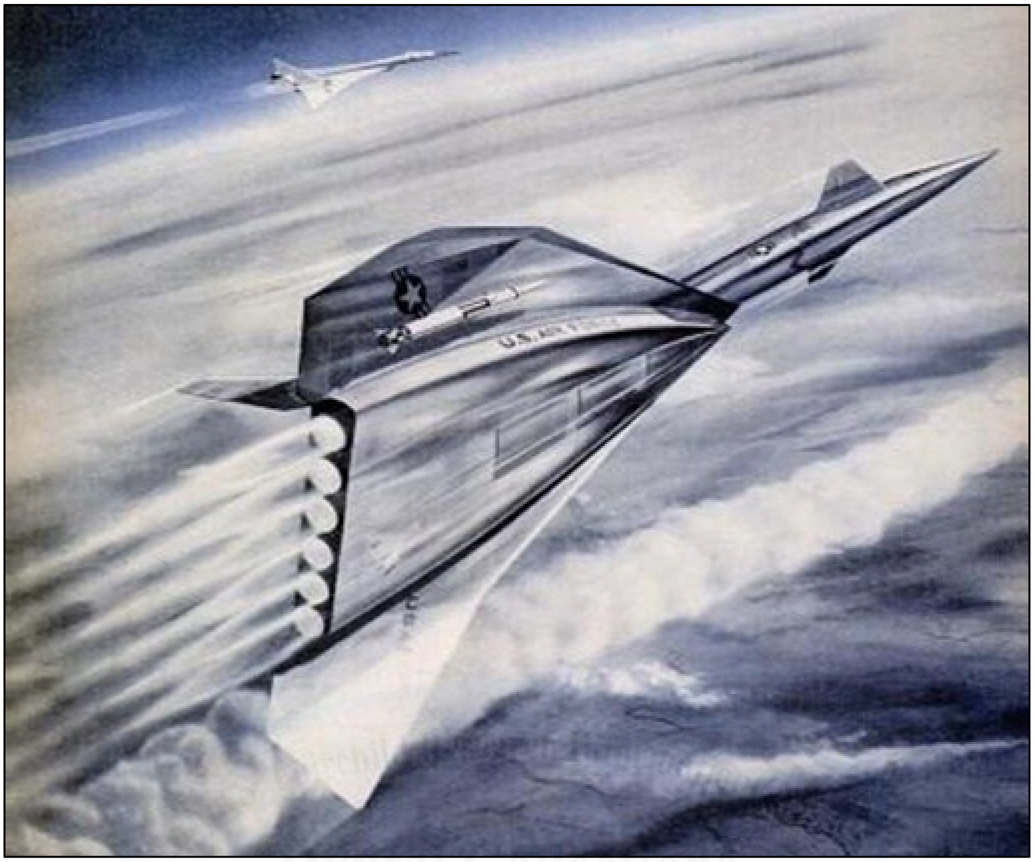

FIGURE 9 – The XB-70 Valkyrie, the Holy Grail of Bombers[421]

The Valkyrie, named after maidens in Norse mythology who flew the skies deciding the outcomes of battles, was the holy grail of bombers, the technical embodiment of the messianic vision of strategic bombardment absolutists. The 250-ton, six-jet, delta-wing plane was designed to fly at more than 2,000 miles per hour (Mach 3), faster than the earth's rotation, while carrying an atomic payload equivalent to almost a 4,000-mile trainload of TNT.[422] "How fast is Mach 3? … At such a speed, you could eat breakfast in New York at eight o'clock, then take off and arrive in Los Angeles an hour and a half 'before' you ate," notes a 1960 *Life* article

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[421] Ed Rees, "The Furor over Fantastic Plane," *Life Magazine*, 17 October 1960, 4.
[422] Mach 1 represents the speed of sound. Mach 3 means three times the speed of sound.

that marveled at the technology.[423] The XB-70 was designed to climb to its cruising altitude fifteen miles above the earth in three minutes and complete a transcontinental weapons delivery in approximately seventy five minutes.[424]

The B-70's costs were as astounding as its performance.[425] If the program had not been cancelled before the production phase, the average cost of a single Valkyrie would have exceeded $24.5 million per aircraft, more than three times the cost of a B-52 it was supposed to replace.[426] In the end, only three prototypes were produced at a whopping program cost of $1.5 billion.

The "bomber mafia," led by LeMay, could not see how its uncompromising insularity over the need to pursue high-end sustaining innovations to its treasured bomber fleet provided less and less value.[427] The following quote from LeMay perfectly captures his single-minded philosophy: "I want the best manned systems I can get. I want the [Valkyrie] very badly … When something faster comes along I want it."[428] From an Army perspective, however, the XB-70, like the nuclear and chemical-powered bombers, was worthless. Even if the high-tech bomber had been designed to carry conventional ordnance, which it wasn't, any bomber that

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[423] Ed M. Miller, "The Gutting of the Valkyrie," *Air Force Magazine*, January 1960, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1960/January%201960/0160valkyrie.aspx.
[424] Ed Rees, "The Furor over Fantastic Plane," *Life Magazine*, 17 October 1960, 125.
[425] Gary Beatovich, "A Case Study of Manned Strategic Bomber Acquisition: The B-70 Valkyrie," Air Force Institute of Technology Dissertation, September 1990, 18.
[426] Ibid. $24.5 million was the anticipated unit cost in 1958. The inflation-adjusted cost in 2012 would be nearly $200 million (see http://www.usinflationcalculator.com). Costs skyrocketed during the B-70's development.
[427] It is a widely believed that the Soviet Union developed the MiG-25 fighter in response to the XB-70, and therefore some the incredible expense of the XB-70 program was somehow worthwhile because it drove the Soviets to make similar fiscal outlays countering the XB-70s capability. But, A. Beyankov, the head of the MiG design bureau, said otherwise. The Mikoyan-Gurevich design bureau accepted the assignment to build the MiG-25 on 10 March 1961. The XB-70 was cancelled well before the MiG-25 reached the prototype stage. The MiG-25 was built because the Soviets thought it would be a useful counter to reconnaissance aircraft like the SR-71 Blackbird. ["Mikoyan-Gurevich MiG-25 Foxbat," http://www.fighter-planes.com/info/mig25_foxbat.htm].
[428] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1961–1984*, Vol. II (Maxwell AFB, AL: Air University Press, 1989), 96.

flew at Mach 3 in the stratosphere could hardly be expected even to see a ground target, let alone perform a visual identification of enemy troops and drop its bombs with the precision required for close air support.

General Thomas Power, LeMay's successor at SAC, echoed his mentor's views. When approached to consider using SAC bombers to support ground operations in Southeast Asia, Power responded, "[Don't] talk to me about that; that's not our life. That's not our business. We don't want to get in the business of dropping any conventional bombs. We are in the nuclear business, and we want to stay there."[429] When Brigadier General John Vogt, a fighter pilot, flew to Offutt Air Force Base, SAC headquarters, to convince Power to explore possibilities for the conventional use of B-52s, Power told him, in a less than friendly manner, to leave. He then issued a directive to banish Vogt from all SAC bases.[430]

One of the few dissenting voices, Colonel James Richardson wrote a 1957 *Air University Quarterly Review* article that lambasted the Air Force's "status quo attitude" and its institutional "tendency to hold what we have rather than risk untested organizational and doctrinal changes."[431]

An internal Air Force study arrived at a similar conclusion as Richardson. It bluntly proclaimed, "… today there is little evidence of any substantive conceptual change nor is the Air

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[429] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 173. SAC deployed 30 B-52s to Guam on February 17, 1965; conventional training in SAC resumed only in late 1963, and the B-52 fleet was slowly converting to a conventional capability [Ibid, 174].
[430] See footnote 63 in Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 181.
[431] Robert C. Richardson III, "In the Looking Glass," A*ir University Quarterly Review*, Vol. 9, No. 4, Winter 1957–1958, 46–47.

Staff now organized so as to best generate and process proposals for change."[432] Air Force planning, the report continued, "has been largely limited to considering the impact of adding forecast weapon systems to projections of current concepts," and the current structure was not capable of giving advice on new strategy and concepts "not influenced by Air Force interests or past Air Force positions and policies."[433] The report concluded that the Air Force had "defensive, status quo, reactionary positions on most issues" and found it hard to "list any policy or strategic goals … that the Air Force is publicly fighting for, other than 'more of the same.'"[434] Likewise, a junior general wrote a scathing indictment of Air Force failures to keep its doctrine dynamic: "The deplorable condition of aerospace power today is to a large extent the result of allowing Air Force doctrine to stagnate and become inapplicable to modern conditions."[435]

Reflecting on his experience, Stuart Symington, an influential Senator and former Secretary of the Air Force, made the following assessment:[436]

> I think one of the tragedies of the Air Force was that some people in it, especially in the 1950s and 1960s … became so wedded to their own thinking that if anybody disagreed, they were hurt. You had former generals around who could remember little but the activities of Eighth Air Force in England, and Fifteenth Air Force in Italy, etc. As a result, tactical air, troop support, air cargo, etc., were not adequately represented.[437]

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[432] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 110.
[433] Ibid.
[434] Ibid.
[435] Major General Dale Smith quoted in Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1961–1984*, Vol. II (Maxwell AFB, AL: Air University Press, 1989), 172.
[436] Robert C. Richardson III, "In the Looking Glass," *Air University Quarterly Review* 9, No. 4 (Winter 1957–1958): 46–47.
[437] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 133.

Expressing similar thoughts as Symington, Eugene Zuckert, the Secretary of the Air Force who served between 1961 and 1965, said the Air Force lacked the vision and vitality it ought to have and thought an "intellectual staleness" had overcome Air Force thinking.[438]

The Air Force's neglect of tactical aviation to support the Army was obvious. The Air Force leadership, increasingly dominated by SAC generals, reassigned all Tactical Air Command (TAC) aircraft to other commands and slashed the number of personnel assigned to the command. At one point, the entire command consisted of a planning staff of sixty-six airmen.[439] General Elwood Quesada, TAC commander and fighter advocate, strenuously objected to the neglect of tactical forces, saying he believed the disintegration of TAC broke Spaatz's promise to Eisenhower that the Army would always enjoy strong tactical air support.[440]

Congress convened hearings in 1949 to examine whether the Air Force was giving inadequate attention to air support of ground forces.[441] Ground commanders testified that they believed the Air Force lacked an effective air-ground control system.[442] They pointed out that tactical air forces earmarked for Army support existed "largely on paper," and that Air force tactical units were not properly trained for their assigned missions.[443] One general warned, "… if war should come tomorrow, the tactical air squadrons of the Navy and Marine Corps would have to provide the major part of the troop support even as they did in the beginning of the last war."[444] Congressman Carl Vinson, the influential chairman of the House

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[438] Michael H. Gorn, *Harnessing the Genie: Science and Technology Forecasting for the Air Force 1944-1986* (Washington, DC: Air Staff Historical Study, Office of Air Force History, 1988), 84.
[439] Ibid, 39.
[440] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 136.
[441] Ibid, 135.
[442] Ibid.
[443] Ibid, 136.
[444] Ibid.

Armed Services Committee, told General Thomas White, then the Air Force director of legislative liaison, that "for its own protection the Air Force would have to meet the Army's requirements for air support."[445] Vinson along with another congressman wrote to General Hoyt Vandenberg, Spaatz's successor, telling him how the House Armed Services Committee was "definitely dissatisfied" with the Air Force and how it had "strong reservations about the efforts of the Air Force to deal with close air support for the Army."[446]

Helicopters Gain a Foothold during the Korean War

The start of hostilities in Korea accentuated the Air Force's inadequate attention to ground support. General Jimmy Doolittle, the hero of the first retaliatory air raid on the Japanese homeland during World War II, wrote to Vandenberg, telling him that it was obvious that the Air Force had been "remiss in not contenting the Army" and that the Air Force "wasn't 'leaning over backward' far enough" on the tactical-air support issue.[447] Complaints from field commanders in Korea centered on the Air Force's slowness in responding to their requests for close air support. Summarizing the Army's complaint, General Matthew Ridgway, the Korean War commander who replaced General Douglas McArthur and who later served as Army chief of staff in 1953, faulted the Air Force for what he "sincerely believed to be an overemphasis on one form of airpower, the long range bomber."[448] He protested that the Air Force showed little interest in developing "low and slow" combat platforms needed by the Army and thus, felt the

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[445] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 307.
[446] Ibid.
[447] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 147.
[448] Ibid, 165.

Army had cause to fill this void on its own.[449] General Mark Clark, Ridgway's successor, echoed Ridgway's sentiments on the Air Force's lack of support and cooperation.[450] Clark complained about the limited range and loiter time of jet fighters and wanted the Air Force to develop specialized aircraft for close air support.[451] An Army spokesman in the Pentagon warned the Army might be "forced" into the "close support business" unless the Air Force changed its thinking.[452] Ridgway directed the Army develop a long-term aviation plan to meet Army requirements on its own.[453]

Although the Army was stripped of the vast majority of its air assets with the passage of the National Security Act of 1947, the legislation that created an independent Air Force included a provision that allowed the Army to develop "such aviation [forces] … as may be organic therein" pursuant to its charter to organize, train, and equip for prompt and sustained combat incident to operations on land.[454] The Army had retained a small, light aircraft for artillery and liaison after the split with the Air Force, but was prevented from rebuilding an organic tactical air force after the Air Force successfully fought to impose ceiling and weight restrictions on Army aircraft during the post-war roles-and-missions negotiations. In return for acknowledging the Army's right to develop its own organic airpower, the Air Force got the Army leadership to sign an agreement in 1949 limiting its fixed-wing aircraft to no more than 2,500

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449 Ibid.
450 General Clark was highly critical of the command setup for air employment. Clark described airpower as "auxiliary weapons, as is the artillery [that] should come under the direct orders of the ground commander" [Mark W. Clark, *Calculated Risk* (New York, NY: Enigma Books, 2007), 134-135].
451 Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 165.
452 Ibid, 165.
453 Ibid, 148.
454 George M. Watson, Jr., *The Office of the Secretary of the Air Force 1947-1965* (Washington, DC: Center for Air Force History, 1993), 290.

pounds and its rotary-wing aircraft to no more than 4,000 lbs.[455] By that point, the Army had acquired a small fleet of helicopters and was adapting them to perform various ground-support missions with increasing fervor.

In September 1950, Army Chief of Staff Joseph Lawton Collins asked Vandenberg to lift weight restrictions so he could purchase larger helicopters for combat cargo operations in Korea. Vandenberg refused, and the matter was referred to the Secretariat for resolution.[456] Under pressure from Secretary of Defense Robert Lovett, Air Force Secretary Thomas Finletter and Army Secretary Frank Pace signed a memorandum of understanding which eliminated weight restrictions on Army aircraft, but defined Army Aviation in terms of functions to be performed within a 50-mile radius of the combat zone.[457]

The Army had little recourse other than appeal to the Secretariat; not only was the Air Force's uncooperative position supported by roles-and-missions delineations, but it also had veto power over Army aviation acquisitions because the Army had to acquire aircraft systems through the Air Force. The Air Force director of requirements repeatedly refused Army acquisition requests for helicopters. General James Gavin, the Army's chief of research and development, recalled one such incident; the Air Force director of requirements responded:

> I am the Director of requirements and I will determine what is needed and what is not. The helicopter is aerodynamically unsound. It is like lifting oneself by one's bootstraps.

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[455] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 148. "In 1946, the War Department Equipment Board determined that Army Ground Forces required four types of helicopters. The types ranged from light liaison to transport helicopters capable of carrying one to three tons and convertible to cargo, passenger, or ambulance use. Three years later, another Army board study expanded these requirements to six types with cargo capacities of up to 25 tons" ["Historical Missions: Army Aviation History," http://www.first-team.us/journals/avn_bde/avnndx01.html].
[456] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 148
[457] Ibid, 149.

> It is no good as an air vehicle and I am not going to procure any. No matter what the Army says, I know what it needs and what it does not need.[458]

"The Air Force's resistance all but stopped the Army from developing heliborne movement," concludes the U.S. Army's Aviation Branch Historian.[459]

In February 1951, the Army leadership met with the Air Force leadership to discuss the development of a light close-support aircraft. Army commanders in Korea, peeved that the Air Force continued to divert its multipurpose tactical fighters from performing close- air-support duties, demanded the Air Force to design an aircraft that could do nothing but this mission; they wanted an aircraft that would always be available when needed. The TAC commander, Lieutenant General John Cannon, however, objected to the procurement of a light close-air support-aircraft. He said that the design would be too vulnerable to participate in an air war.[460] "It appears infinitely wise," said Cannon, "to direct our efforts toward removing present obstacles to the accomplishment of the missions of tactical air by aircraft types which are inherently capable of such accomplishment than to design aircraft of reduced utility and performance in order to accept basic inadequacies."[461] Unsatisfied with the Air Force's position, General Clark responded:

> The traditional Air Force doctrine, which provides for coequal command status between ground and air at all but theater levels, constitutes a fundamental defect in command relationship. This doctrine by mutual cooperation is unacceptable because it serves to the supporting arm the authority to determine whether or not a supporting task should be executed. The theory of divided command in the face of the enemy is foreign to the

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[458] James M. Gavin, *War and Peace in the Space Age* (New York, NY: Harper and Brother, 1958), 110-111.
[459] James W. Bradin, *From Hot air to Hellfire: The History of Army Attack Aviation* (Novato, CA: Presidio Press, 1994), 77.
[460] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. II (Maxwell AFB, AL.: Air University Press, 1989), 308.
[461] Ibid, 308-309.

> basic concept of warfare wherein the responsible commander exercises undisputed direct authority over all elements essential to the accomplishment of his mission.[462]

Brigadier General Homer Sanders, TAC's deputy chief of staff for operations, pointed out that Clark's request for support on a one-for-one basis for each division would have resulted in a requirement for more than 100 dedicated air units in Western Europe during 1944-45 European campaign alone.[463]

In November 1952, Army Secretary Frank Pace and Air Force Secretary Thomas Finletter signed another memorandum of understanding reinstating the weight restrictions for Army aircraft at 5,000 pounds. In exchange for agreeing to a reinstated weight limit, the Army negotiated an expanded operating area. Previously limited to 50 miles, the new agreement expanded the definition of the "combat zone" from 50 miles to "50 to 100 miles in depth." After signing the agreement, the Army was allowed to proceed with plans to stand up twelve helicopter-transport battalions to support operations, and the units were immediately send to Korea.[464] The Army interpreted the 1952 Pace-Finletter memorandum as giving it free rein to develop fully the potential of light aviation within its combat units. When fighting in Korea ceased in July 1953, the Army's aviation inventory had quadrupled to more than 3,000, of which almost 1,000 were helicopters.[465]

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[462] General Mark W. Clark to Army Chief of Staff, subject: Tactical Air Support of Ground Forces, letter, 13 September 1951.
[463] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. II (Maxwell AFB, AL: Air University Press, 1989), 309.
[464] Ibid.
[465] Ibid. Helicopters represented 5% of the Army's aircraft inventory at the start of the Korean War and 31% at the end [Richard P. Weinert, *History of Army Aviation 1950-1962, Phase II: 1955-1962* (Fort Monroe, VA: Historical Office of the Chief of Staff, U.S. Army Training and Doctrine Command, November 1976), 1]. See also Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 149.

Stage Set for Exponential Growth

After Korea, Ridgway, Clark, and other senior Army leaders openly called for the Army to aggressively rebuild its organic air forces.[466] Fed up with the Air Force's lack of commitment to provide air support to Army ground troops and unable to compensate entirely through the use of alternatives such as artillery, Ridgway, in September 1954, directed a comprehensive review of the Army aviation program. The review led to the development of the *Army Aviation Plan, FY 1956-1960*, which called for an expansion of the service's aviation fleet from 3,516 to 8,486 aircraft.

General Maxwell Taylor, who took over as Army chief from his mentor Ridgway in 1955, championed the Army's rebuilding of its organic airpower capability. Instead of taking over obsolescent weapons and equipment used by the Air Force, Taylor thought the Army should develop its own resources and technology. Taylor summarized his reasoning in the following passage from his book *The Uncertain Trumpet*:

> Since 1947 … the Army has been dependent upon the Air Force for tactical air support, tactical air lift, and for long-range air transport. Throughout this period, the Army has been a dissatisfied customer, feeling that the Air Force has not fully discharged its obligations undertaken at the time of unification. The Air Force, having something which the Army wanted, has been in a position to put a price upon cooperation and to insist upon acquiescence in Air Force views on such controversial issues as air-ground support procedures, air resupply, and control of air space over the battlefield. As technical improvements in weapons and equipment offered the Army the possibility of escaping from dependence upon the Air Force, the latter has vigorously resisted these efforts and has succeeded in obtaining the support of the Secretary of Defense in imposing limitations on the size and weight of aircraft procured by the Army, on the ranges of Army missiles, and on the radius of Army activities in advance of the front line of combat. As a result of the controversies arising from the dependence of the Army on the Air Force, the two services have been constantly at loggerheads. They have been

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[466] In an influential article published in 1954, General James Gavin, the Army's chief of research and development, called for the use of mechanized troops transported by air to become a modern form of cavalry [James M. Gavin, "Cavalry, and I Don't Mean Horses," *Harper's Magazine*, April 1954, 54-60, available at http://www.combatreform.org/cavalryandidontmeanhorses.htm].

> unable to agree on a doctrine for cooperation in battle. They are at odds as to the adequacy of levels of Air Force support for the Army, and as to the suitability of types of Air Force equipment to furnish this support. Because of the very high performance of their airplanes, designed primarily to meet the needs of air battle today, the Air Force is not equipped to discharge its responsibilities to the Army in ground combat. Having witnessed this unhappy state of affairs for over a decade, I am convinced that the Army must be freed from this tutelage and receive all the organic means habitually necessary for prompt and sustained combat on the ground. It should have its own organic tactical air support and tactical air lift, or rather the new weapons and equipment which will perform the functions presently comprehended under those two headings. Special restrictions of size, weight, and in the case of weapons, of range should be abolished forever and the Army encouraged to exploit technology to the maximum to improve its weapons and equipment habitually necessary for prompt and sustained ground combat. It is essential to end the present fragmentation of the land force function, particularly at a time when the role of land forces should assume increased importance under the strategy of Flexible Response.[467]

Taylor pressed the Secretary of Defense to rewrite the Army's assigned roles and missions so they included "the land itself and the contiguous layers of air and sea necessary for use in ground operations."[468] He thought each service had the right to develop all weapons and equipment that were habitually necessary for combat in its particular medium.[469] Taylor reorganized Army aviation, appointing Lieutenant General Hamilton Howze as its first director, and he got Congress to grant the Army the authority to train fixed-wing and helicopter pilots independent of the Air Force.[470]

At Taylor's urging, Army Secretary Wilber Brucker made a request to Secretary of Defense Charles Wilson that he completely lift any and all weight restrictions on Army aircraft.[471] Wilson, however, denied Brucker's request, and in November 1956, issued a

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467 Maxwell D. Taylor, *The Uncertain Trumpet* (Westport, CT: Greenwood Press, 1974), 168-170.
468 Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 183.
469 Ibid.
470 Ibid, 174.
471 Richard P. Weinert, *History of Army Aviation 1950-1962, Phase II: 1955-1962* (Fort Monroe, VA: Historical Office of the Chief of Staff, U.S. Army Training and Doctrine Command, November 1976), 16. In May 1955, General Ridgway announced a plan to acquire ten T-37 fixed-wing jets to test them in a reconnaissance role.

directive that put a crimp in the Army's aviation-expansion plans. The directive (later republished as Defense Directive 5160.22, dated March 18, 1957) expressly prohibited the Army from developing any aircraft to perform close air support. Wilson understood why the Army made the request and was sensitive to the Army's perceived lack of support, so in his directive, he included specific language reminding the Air Force that one of its primary responsibilities was to furnish close-combat and logistical air support for the Army.[472] Wilson also relaxed weight restrictions on Army aircraft, increasing the restriction on the maximum empty weight of its fixed-winged planes to 5,000 pounds and the restriction on the empty weight of its rotary-wing aircraft to 20,000 pounds.[473] Additionally, Wilson promised the Army that he would consider exceptions to these weight limits on a case-by-case basis and immediately authorized the Army to procure five de Havilland DHC-4 Twin Otters, 7500-pound aircraft. Subsequently, the Army was granted approval to acquire 15,000-pound Caribou transport and 9,000-pound Mohawk turboprop observation aircraft.[474] The acquisition of the Caribou aircraft was especially significant because, as discussed later in the chapter, the Army later traded its fleet of Caribou transport aircraft to the Air Force as part of McConnell-Johnson agreement in 1966 to end restrictions on its acquisition of helicopters.

General Twining, the Air Force chief of staff, immediately objected, and Secretary of Defense Wilson ordered the Army to stop procurement of the jets. The Army eventually succeeded in negotiating to borrow several jets from the Air Force for test purposes, but did not follow through with their acquisition because the Army leadership was "convinced that Air Force opposition had so influenced the thinking of the Joint Chiefs of Staff and the Department of Defense that it was not feasible to pursue the project" [Ibid, 165].

[472] Richard I. Wolf, *The United States Air Force: Basic Documents on Roles and Missions* (Washington, DC: Air Staff Historical Study, 1987), 320.

[473] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1961–1984*, Vol. II (Maxwell AFB, AL Air University Press, 1989), 176-177.

[474] Ibid, 516-518. The De Havilland Caribou was the largest Army fixed-wing aircraft. The Army procured 173Caribou aircraft in 1959. Initially designated AC-1, the Caribou was re-designated CV-2 in 1962; the aircraft retained that designation for the remainder of its Army career. When responsibility for all fixed-wing tactical transports was transferred to the U.S. Air Force, the Caribou received the designation C-7.

General Lyman Lemnitzer, Taylor's successor as Army chief, continued Army opposition to any weight limits for its aircraft.[475] During congressional testimony, Lemnitzer stated:

> The Army does not consider it advisable or desirable to have weight limitations imposed on any Army aircraft. … Despite the fact that two exceptions to the aircraft have been authorized by the Secretary of Defense . . . the weight limitations have inhibited the thinking of Army planners and the initiative of the aircraft industry to produce new aircraft for the Army.[476]

Lemnitzer charged that equipping, training, and deploying tactical fighters for atomic war caused TAC to ignore its responsibility to support ground forces.[477] A few junior fighter generals in the Air Force agreed with the Army complaints, but they were overruled by more powerful factions who thought preparing for atomic war superseded all other requirements.[478]

Lemnitzer established a review board, headed by Lieutenant General Gordon Rogers, to study the Army's aviation requirements. The Rogers Board recommended the Army purchase the Bell UH-1 "Huey" and the CH-47 Chinook. Additionally, the Rogers Board recommended developing and testing "air cavalry" units for combat.[479]

The Bell UH-1 was the first Army helicopter to benefit from a turbine engine, a technological breakthrough that abruptly shifted the relative advantage offered by rotary-wing

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[475] General Lemnitzer served as the Army's chief of staff from 1957 to 1960. In 1960, he was selected to serve as the chairman of the Joints Chiefs of Staff.
[476] House, "United States Defense Policies in 1960," 87th Congress, 1st session, 1961, 27-28.
[477] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 183.
[478] Ibid.
[479] "The UH-1 would change the Army and is arguably the most important aircraft the Army ever procured, with many still flying today" [Frank W. Tate, "Army Aviation as a Branch, Eighteen Years After the Decision," School of Advanced Military Studies Monograph, 2000, 11. The first three helicopters off the assembly line received the XH-40 designation. "When the Army adopted its own two-letter designation system, the H-40 became the HU-1 (Helicopter Utility). From this designation came "Huey," the name by which it has remained known. The DoD standardized and unified designation system adopted in 1962 reversed this to UH-1, the first designation in the new DoD helicopter series" ["Iroquois (Huey) History," http://www.globalsecurity.org/military/systems/aircraft/uh-1-history.htm].

aircraft.[480] The piston-driven engines powering helicopters that supported the Korean War, like the H-23 Raven, produced only one horsepower for every three pounds of engine weight.[481] As a result, engine power severely limited performance. The H-23 Raven, for example, could not pick itself up to a hover on a warm day. H-23 pilots had to routinely make running takeoffs, skimming along the ground until the helicopter achieved enough lift to get airborne. Although the H-23's engine supposedly was designed to carry a pilot and two artillery observers, its actual carrying capacity, depending on the temperature, often amounted to one passenger besides the pilot.[482] The turbine-powered UH-1 literally reversed the horsepower-to-engine weight ratio of previous Army helicopters; instead of a 1-3 ratio, the Huey offered more than 3-1.[483] In sharp contrast to Korean War-era helicopters that could barely carry a pilot and a passenger, later versions of UH-1 could carry twelve combat-loaded troops and a crew of two. The UH-1 first flew in 1956 and entered production in 1959.

In a move that irritated many men in Air Force blue, General Thomas White, who was then chief of the service, on his own initiative, approached General George Decker, who replaced Lemnitzer as Army chief after Lemnitzer was appointed chairman of the joint chiefs of staff in September 1960, with a proposal to allow the Army to pick a ground-support aircraft for

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[480] Unlike early military aircraft, which benefited from technological advancements in a growing commercial market for aviation, the commercial market for helicopters remained relatively small. One author notes: "The expansion of Army helicopter use hit delays caused by the immaturity of the whole helicopter industry. The lack of a commercial market in the late 1940s and the Air Force's thwarting Army acquisitions had kept the number of helicopter producers and production lines small" [James W. Williams, *A History of Army Aviation: From Its Beginnings to the War on Terror* (Lincoln, NE: iUniverse, 2005), 60].

[481] "Iroquois (Huey) History," http://www.globalsecurity.org/military/systems/aircraft/uh-1-history.htm.

[482] James W. Williams, *A History of Army Aviation: From Its Beginnings to the War on Terror* (Lincoln, NE: iUniverse, 2005), 61.

[483] The UH-1 has a 305-pound engine. The HU-1B's engine produced 960 horsepower. The UH-1C engine produced over 1,000 horsepower, and the UH-1D more than 1400 [["Iroquois (Huey) History," http://www.globalsecurity.org/military/systems/aircraft/uh-1-history.htm].

eleven Air Force squadrons.[484] White was convinced that working out differences with the Army was best for the United States and in the long run good for the Air Force.[485] Decker declined the offer, saying it was not enough just to pick the aircraft. He wanted guarantees that these squadrons would be assigned to Army control. Besides, the Army was already well on its way to developing its own organic air forces which would allow it to cut, or at least lessen, its dependence on the Air Force. Declining the offer also meant that he would not be endorsing one of the eight high-performance jets that White suggested. Furthermore, saying "no" left more options on the table for the Army to potentially develop its own fixed-wing close-air-support aircraft at a later time, an option it explored.[486]

In 1961, shortly after President John Kennedy assumed office, the Army invited the president to watch a helicopter firepower demonstration. Accompanied by Secretary of Defense Robert McNamara, Kennedy praised the Army's innovation and said it ought to have more gunships.[487] McNamara subsequently made it clear he did not intend to enforce DoD Directive 5160.22; although the directive was not formally rescinded until 1971, the Army assumed the directive was dead based on McNamara's comments.[488] McNamara believed in selecting weapon systems by "dealing not with absolutes but with comparatives."[489]

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484 Claude Witze, "Just What the Air Force Needed," *Air Force Magazine*, July 1961, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1961/July%201961/0761white.aspx.

485 Ibid. White's motives were not as altruistic as he suggests. White made the offer, in part, because it was likely that the Air Force was going to lose the squadrons in the upcoming budget. Thus, he perceived the Air Force had nothing really to lose in extending the offer. Making concessions to the Army was preferable to losing the squadron to inactive status.

486 Alfred Goldberg and Donald Smith, "Army-Air Force Relations: The Close Air Support Issue," RAND Project Air Force report, October 1971, 18-19.

487 Frank W. Tate, "Army Aviation as a Branch, Eighteen Years After the Decision," School of Advanced Military Studies Monograph, 2000, 10.

488 Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1961–1984*, Vol. II (Maxwell AFB, AL: Air University Press, 1989), 517.

489 Quoted in Gary Beatovich, "A Case Study of Manned Strategic Bomber Acquisition: The B-70 Valkyrie," Air Force Institute of Technology Dissertation, September 1990, 38.

McNamara explained, “We must always take into account not only the planned capabilities of the proposed weapon system, but also its full cost in comparison to the cost and effectiveness of other weapon systems which can do the same job, perhaps in somewhat different ways.”[490] Despite Air Force protests, McNamara authorized the Army to test and evaluate a number of jet fighters, including a British Vertical/Short Take-off and Landing prototype fighter, the P-1127, for close air support.[491] Additionally, McNamara pressed the Army to give more attention to developing an organic airmobility capability, and as a result, the Army convened the Tactical Mobility Requirements Board, commonly known as the “Howze Board.” Completing its work in August 1962, the board concluded, "Adoption by the Army of the airmobile concept—however imperfectly it may be described and justified in this report—is necessary and desirable. In some respects, the transition [from ground to air mobility] is inevitable just as was that from animal mobility to motor."[492]

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[490] Ibid.
[491] The P-1127 was a predecessor to the British Harrier “Jump Jet.”
[492] Charles R. Shrader, *History of Operations Research in the United States Army Volume II: 1961-1973* (Washington, DC: U.S. Government Printing Office, 2008), 271. “The Howze Board recommended the organization of two new types of completely airmobile Army units. These would be air assault divisions, each with 459 organic aircraft, and air cavalry combat brigades, each with 316 aircraft. It also stated a requirement for two new types of special purpose Army air units; air transport brigades, each with 134 aircraft, and corps aviation brigades, each with 207 aircraft. The board visualized that the air assault division would employ air-transportable weapons together with armed helicopters and fixed-wing aircraft as a substitute for conventional ground artillery. The air assault division also would be allotted 24 Mohawk aircraft to perform a ‘very close’ support mission for its own troops. Possessing a very high degree of tactical mobility, the air assault division would be able to make deep penetrations into enemy territory, to outflank an enemy by moving over inaccessible terrain and executing quick-strike delaying actions, or to serve as a highly mobile combat reserve for other more conventional divisions. Even though the air assault division probably would be able to perform most of the missions expected of airborne divisions, it would be particularly valuable for conflicts outside of Europe. The air cavalry brigade would be equipped with a large number of helicopters, and the brigade would be useful for attacks against an enemy's flanks, rear areas, and armored penetrations, since it would have large numbers of antitank weapons - including missiles - mounted on its helicopters. Each air assault division would be supported by an air transport brigade, which would have 54 helicopters and 80 AC-1 Caribou light-transport aircraft. The brigade would pick up cargo delivered by Air Force aircraft and carry it forward to the ground troops. Under this concept the Air Force would provide ‘wholesale’ distribution of cargo, and the Army air transport brigade would "retail" the cargo to frontline units” [Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1961–1984*, Vol. II (Maxwell AFB, AL: Air University Press, 1989), 181].

Curtis LeMay, who at that point had taken over from White as Air Force chief, vehemently protested the Howze Board's conclusions, complaining, "What the Howze Board Report is advocating, I think is in effect building another Air Force for the Army."[493] Yet, LeMay was unwilling to take away resources from his bombers to fund tactical air assets designed principally to support the army, nor was he excited about having his nuclear bombers pick up a conventional role. On more than one occasion, LeMay remarked, "I think that your strategic forces must come first."[494]

When McNamara, supported by President Kennedy, cancelled the XB-70, LeMay was livid and immediately engaged in a tooth-and-nail struggle to save his "dream bomber."[495] LeMay attempted to end-run the administration by lobbying Congress to mandate the defense department reinstate the bomber contract. In January 1962, McNamara was called to testify in front of the House Armed Services Committee on the issue, and he re-affirmed the administration's position. "We have again restudied the role of the B-70 in our future strategic retaliatory forces and again have reached the conclusion that the B-70 will not provide enough

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[493] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1961–1984*, Vol. II (Maxwell AFB, AL: Air University Press, 1989), 181. The Air Force also responded to the Howze Board with a board of its own. The Disosway Board, headed by General Gabriel Disosway, criticized the Howze Board's recommendations as "a call for another air force" and criticized "the attempt to parcel out aviation to ground commanders as a serious violation of one of the agreed-upon lessons of World War II: the centralized control of air power" [Kenneth P. Werrell, *Chasing the Silver Bullet* (Washington, DC: Smithsonian Books, 2003), 103].

[494] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1961–1984*, Vol. II (Maxwell AFB, AL: Air University Press, 1989), 48.

[495] Walter J. Boyne, "LeMay's Dream Bomber," *Aviation History*, 10 November 2009, available at http://www.historynet.com/lemays-dream-bomber.htm. During the Eisenhower administration, General White cut the B-70 program "to the bone" ["Air Force Pares B-70 Plan to Bone: Heavy-Bomber Program All but Canceled," *New York Times*, 2 December 1959, 22. White had previously cancelled the F-108, a Mach 3 fighter. The B-70 and F-108 programs were closely coordinated. The costs of developing advanced engines, fuel systems, and escape capsules for the B-70 were supposed to be covered by F-108 funds. Cancelling the F-108 meant that $180 million was immediately added to the B-70's costs at a time when it was already struggling to stay cost-effective. The B-70 program was pared back to produce a limited number of prototypes. LeMay tried to revive the program, rebranding the aircraft as the RS-70, a supersonic surveillance plane designed to fly over the Soviet Union looking for mobile ICBMs. Kennedy had made a campaign promise to build the XB-70, but reversed himself once he got elected.

of an increase in our offensive capabilities to justify its very high cost," McNamara testified.[496] President Kennedy had previously released an official statement asserting America's growing ICBM capability "makes unnecessary and economically unjustifiable the development of the B-70 as a full weapons system."[497] When it was his turn to testify, LeMay contradicted both the President and his civilian boss at the defense department, telling both the House and Senate armed services committees that he thought the XB-70 was vital to the nation's security. Betrayed, McNamara chastised LeMay. LeMay, however, paid little heed to the reprimand and continued his congressional lobbying efforts. LeMay secured the support of twenty one members of Congress who were projected to gain work in their districts from the production of the Valkyrie. These congressmen inserted language in an appropriations bill to direct, by law, the executive branch to spend the full amount of the nearly $500 million on purchasing the new bomber. McNamara refused to spend the money. President John Kennedy had to personally intervene to kill the program. He convinced House Armed Service Committee chairman Carl Vinson to retract the bill's language.

LeMay's political maneuvering left a great deal of ill will in its aftermath and set back attempts by the Air Force to move on to a new bomber program.[498] LeMay, to use a slang expression, shot his wad over the B-70 and no longer had any friends within the administration. The Army seized the political opportunity to bolster civilian support for its efforts to rebuild its

[496] Gary Beatovich, "A Case Study of Manned Strategic Bomber Acquisition: The B-70 Valkyrie," Air Force Institute of Technology Dissertation, September 1990, 42.
[497] John F. Kennedy, "99 - Special Message to the Congress on the Defense Budget" (speech, Congress, Washington, DC), 28 March 1961, available at http://www.presidency.ucsb.edu/ws/index.php?pid=8554#axzz1s79eBmzK.
[498] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 120.

organic aviation force, and McNamara gave the Army free rein to develop rotary-wing capabilities for the build-up in Europe and the budding counterinsurgency in Southeast Asia.[499]

Exponential Growth

In 1961, the Army began what would become a massive buildup of its aviation assets to support the Vietnam War. Between 1962 and 1966, the Army doubled its helicopter fleet to more than 5,000 machines (see Figure 10). By 1970, the Army had acquired 10,000 helicopters, a figure that does not include combat losses. According to Pentagon figures, the Army lost 4,643 helicopters in action during the conflict, so the total procurement was closer to 15,000.[500] During the war, helicopters blossomed from fulfilling a peripheral role to serve a prominent and indeed defining combat role. Iconic images of Bell UH-1 H "Hueys" conducting air assault landings on hot landing zones (see Figure 11) while helicopter gunships orbited overhead came to symbolize the Vietnam War; helicopters flew more than 36 million hours in support of the war.[501] By the end of the conflict, the Army had more pilots on active duty than the Air Force.[502]

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499 Warren A. Trest, Air Force Roles and Missions: A History (Washington, DC: Air Force History and Museums Program, 1989), 193. Escalating U.S. involvement in Vietnam made the gross disconnect between the demands of the "bomber mafia" for nuclear bombers that flew higher, faster, and farther and the needs of ground forces very apparent. Mounting casualties in Vietnam put the Air Force in a bind, highlighting the Air Force's unwillingness to devote substantial resources to ground support. The service found itself without a convincing rebuttal to the national viewpoint [Morton H. Halperin, Priscilla Clapp, and Arnold Kanter, *Bureaucratic Politics and Foreign Policy* (Washington, DC: Brookings Institute, 1974), 46].

500 James F. Dunnigan and Albert A. Nofi, *Dirty Little Secrets About the Vietnam War: Military Information You are Not Supposed to Know* (New York, New York: St. Martin's Press, 1999), 109. Another 6,000 helicopters were so severely damaged that they required extensive rebuilding.

501 Ibid.

502 Peter Brush, "The Helicopter Road to Vietnam," *Viet Nam Generation*, Vol. 6, 1995, http://www.library.vanderbilt.edu/central/Brush/Helicopters-Vietnam.htm.

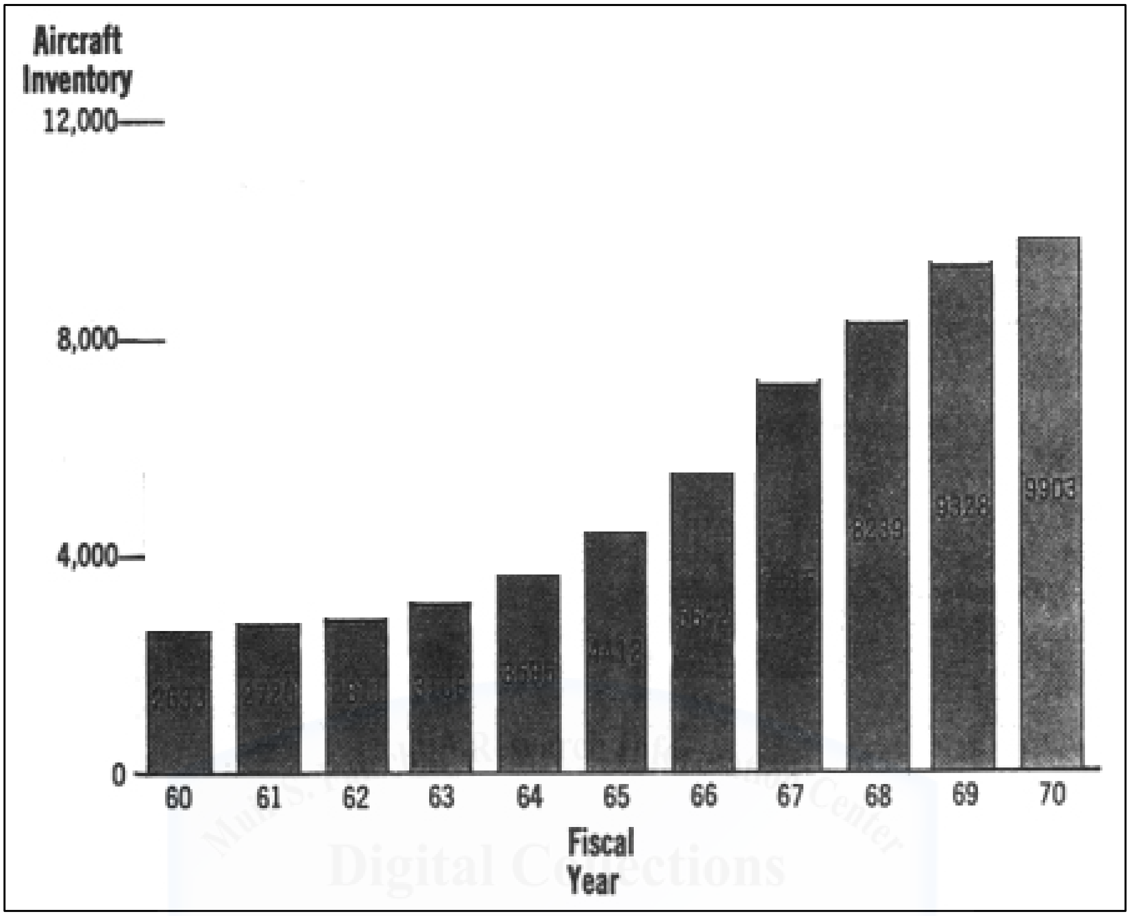

FIGURE 10 – Exponential Growth of Helicopters within the U.S. Army during the 1960s[503]

503 Source: derived from Chart 5 in Joseph M. Heiser, Jr., *Logistics Support* (Washington, DC: Department of the Army, 1991), available at http://www.history.army.mil/books/Vietnam/logistic/chapter5.htm.

FIGURE 11 – The Iconic "Huey," a Helicopter that Symbolized the War in Vietnam

ASSESSING EXPLANATORY VALUE

The Insufficiency of Coté, Posen, and Rosen

Although insightful, the three standard political science theories put forth by Coté, Posen, and Rosen provide incomplete explanations for the U.S Army's adoption of the helicopter. The problem with using Coté's theory to explain the adoption of helicopters within the U.S. military is that helicopters experienced exponential growth precisely at a time when Coté's theory suggests it would have been most difficult. Coté asserts that the service chiefs, in response to Secretary of Defense Robert McNamara's efforts in the early 1960s to strengthen civilian control of the military, banded together so that they could preserve as much autonomy

for themselves as possible.[504] He claims interservice competition essentially ceased with the appointment of General Earle Wheeler as the Chairman of the Joints Chiefs in 1964.[505] Wheeler suppressed interservice disagreement, instituting a tacit rule of unanimity where senior uniformed leaders worked out compromises internally in order to present a unified front to their civilian overseers. Coté concludes that this collusive behavior, which has since become the norm, stifles innovation. According to the Army records, since 1965, the Army Aviation Program experienced an "unprecedented" acceleration of helicopter production, deployments, and utilization.[506] In other words, helicopters experienced "unprecedented" growth immediately after Coté says McNamara, to use a game theory analogy, "taught the services the solution to the prisoner's dilemma by forcing them to discover the powers of cooperation" (see Figure 10).[507] According to his theory, this should have stifled any innovation, yet it did not. Indeed, the opposite occurred.

Not only did helicopters experience "unprecedented" growth exactly when Coté says the senior uniformed leaders of the armed services institutionalized a *general* practice of innovation-stifling cooperation, they also continued to experience exponential growth immediately after the Army and Air Force reached a *specific* agreement not to compete over rotary-wing aircraft. Air Force Chief of Staff John McConnell and the Army Chief of Staff Harold Johnson signed a formal non-competition agreement on April 6, 1966. By agreeing to the

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[504] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 371.
[505] Ibid, 18.
[506] Joseph M. Heiser, Jr., *Logistics Support* (Washington, DC: Department of the Army, 1991), available at http://www.history.army.mil/books/Vietnam/logistic/chapter5.htm. The agreement contained an exception for the Air Force to acquire and employ helicopters in support of special air warfare, search and rescue, and administrative support.
[507] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 371.

binding accord, the Air Force relinquished all claims for helicopters and follow-on rotary-wing aircraft which were designed and operated for intra-theater movement, fire support, supply, and resupply of Army forces and Air Force control elements assigned to the Army's Direct Air Support Center.[508] In exchange, the Army agreed to relinquish all claims for CV-2 and CV-7 aircraft and for future fixed-wing aircraft designed for tactical airlift.[509] Additionally, it agreed to transfer its fleet of CV-2 and CV-7 intra-theater transport aircraft to the Air Force.[510] Coté's theory predicts this cooperative agreement would stifle innovation, yet helicopters continued to experienced exponential growth subsequent to agreement. Moreover, the agreement opened the way for the Army to innovate and develop dedicated helicopter gunships.

Immediately after signing the McConnell-Johnson agreement, the Army took advantage of the clause that gave it the right to develop helicopters to provide fire support and announced plans to develop dedicated helicopter gunships. The Army awarded Bell Helicopter Company a contract to produce 110 AH-1G Cobras, first-generation gunships.[511] Prior to the Cobra, the Army had experimented with arming helicopters, but thus far that had meant only strapping rockets and machine guns onto utility helicopters such as the UH-1.[512] The Army also announced plans to develop the AH-56A Cheyenne, an even more advanced helicopter gunship capable of flying at 200 knots. It awarded a contract to Lockheed to develop 10 AH-56A prototypes for testing.

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[508] Richard I. Wolf, *The United States Air Force: Basic Documents on Roles and Missions* (Washington, DC: Office of Air Force History, 1987), 382.
[509] Ibid.
[510] Ibid. The Air Force won airplanes they did not need and that were incompatible with their view of what an airlift airplane should be.
[511] The contract was awarded on April 13, 1966.
[512] Kenneth P. Werrell, *Chasing the Silver Bullet* (Washington, DC: Smithsonian Books, 2003), 106. The Huey and the Cobra were the first Army helicopters to use turbine engines, a technology that revolutionized helicopter performance and reliability [Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 90].

General William Momyer, the commander of Tactical Air Command (TAC), thought the Army had pulled the wool over McConnell's eyes with the non-competition agreement.[513] Momyer thought that McConnell had not visualized that the helicopter was going to be utilized and turned into the kind of firepower platform that materialized in the Cobra and the Cheyenne.[514] The Air Force, whose heart was never into acquiring helicopters, responded to the challenge not by developing its own helicopter gunship, but by developing a subsonic, fixed-wing, specialized, close-air-support aircraft called the A-10 Thunderbolt II. Lieutenant General Otto Glasser, the Air Force deputy chief of staff for research and development said, "I am personally totally convinced, perhaps parochially so, that [the A-10] will do 80 to 90 percent of all the missions of the Cheyenne … at one-third the costs."[515]

Undeniably, the Cheyenne was the most important incentive behind the Air Force's push for the A-10, and thus, Coté's theory helps explain what drove the Air Force to develop an aircraft that it would otherwise not have acquired. But, Coté's theory does not account for the Army's embrace of the helicopter.[516] The A-10 beat the Cheyenne in a heated competition, and as a result, Congress cancelled the helicopter in 1972, prior to production.

To summarize, the Air Force deferred to the Army when it came to the development of helicopters and even signed a non-competition agreement. Contrary to Coté's theory, however, helicopters experienced "unprecedented" growth immediately afterwards. In the

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[513] Before serving as TAC commander, Momyer was the deputy commander for air operations, Military Assistance Command, Vietnam.
[514] Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1961-1984*, Vol. II (Maxwell AFB, AL: Air University Press, 1989), 519.
[515] Ibid, 687.
[516] Kenneth P. Werrell, *Chasing the Silver Bullet* (Washington, DC: Smithsonian Books, 2003), 106.

only area where the two services competed—the competition between the Cheyenne and the A-10—the Air Force won, which stifled rotary-wing aviation innovation.

Similar to Owen Coté's theory, Barry Posen's model of military innovation does not entirely explain when and why the Army adopted helicopters. Posen argues that innovation is unlikely to occur in the absence of civilian intervention. On the surface, the development of helicopter aviation in the U.S. Army appears to have been the result of a biting memo Secretary McNamara sent to the army leadership on April 19, 1962 stating, "I have not been satisfied with Army program submissions for tactical mobility. I do not believe the Army has fully explored the revolutionary opportunities offered by aeronautical technology for making a revolutionary break with traditional surface mobility means. Air vehicles operating close to, but above the ground appear to me to offer the possibility of a quantum increase in effectiveness."[517] McNamara continues, "I therefore believe that the Army's reexamination of its aviation requirements should be a bold 'new look' at land warfare mobility. It should be conducted in an atmosphere divorced from its traditional viewpoints and past policies."[518] McNamara convened the Howze Board, which was stacked with well-known helicopter advocates, to study Army aviation requirements and develop recommendations. The board not surprisingly returned a recommendation that the Army should develop airmobile divisions in which the helicopter would take on a prominent role.

Certainly, McNamara played an influential role in accelerating the Army's adoption of helicopters, but he did not provide the spark for change. Stated differently, McNamara's memo

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[517] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 86.
[518] Ibid.

and subsequent actions helped overcome obstacles created by conservative officers and the tendency to protect resources devoted to traditional missions, but he did not initiate Army interest in the adoption of the helicopter.[519] The U.S. Army acquired its first helicopters in 1947, fifteen years before McNamara wrote his memo.[520] At the start of hostilities in Korea in 1950, the Army had 56 helicopters.[521] Three years later, the Army had acquired approximately 1,000 helicopters.[522] A decade later, when McNamara wrote his memo, the Army already had approximately 3,000 helicopters in its inventory. In short, McNamara played a role in the final stages of this innovation and helped win the endgame in the struggle to create combat units utilizing helicopters, but his intervention does not entirely account for the adoption of helicopters within the Army.[523]

Lastly, Stephen Rosen's theory, like the other two, provides insights into what led the U.S. Army to adopt helicopters; but his theory does not completely describe when and why the Army adopted helicopters. In fact, Rosen's main conclusion does not match the historical record. There is no doubt, as Rosen argues, that the recruitment of officers on a "fast-track" promotion path who "commanded the respect of traditional leaders of the army … and [who] were sympathetic to airmobility" into aviation helped accelerate the innovation's adoption.[524]

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[519] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 85-86.

[520] "While the Army Air Forces, the Navy, and the Coast Guard acquired helicopters during World War II, Army aviation did not acquire its first one until 1947. … In 1946, the War Department Equipment Board determined that Army Ground Forces required four types of helicopters. … Because of the shortage of helicopters and the reluctance of the US Air Force to purchase them for the ground forces, the Army did not acquire its first helicopter, an experimental model of the two-place H-13 Sioux, until 1947" ["Historical Missions: Army Aviation History," http://www.first-team.us/journals/avn_bde/avnndx01.html].

[521] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 148.

[522] Ibid, 149.

[523] I Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 91-92.

[524] Ibid, 87.

But, Rosen goes beyond that assertion and claims the credit for the adoption of helicopters should go to a group of senior officers who, starting in 1955, made a "conscious effort … to restructure career paths in army aviation."[525] Broadly, Rosen's central thesis is that the creation of new promotion paths is an indispensable prerequisite for military innovation.[526] He emphatically declares change occurs at a generational pace, proceeding "only as fast as young officers rise to the top."[527] Examining the history of helicopters within the U.S Army, however, reveals a disconnect between Rosen's hypothesis and what actually happened. First, as previously noted, the adoption of helicopters began several years before the 1955 date Rosen suggests the Army became interested in rotary aviation. By 1955, the Army had already acquired well over 1,000 helicopters.

Second, the Army adopted helicopters despite its promotion system, not because of it. Credit belongs to senior army officers for their visionary leadership in embracing helicopters, but they did not orchestrate the adoption of helicopters through systemic changes in the Army's promotion paths. In other words, they did not re-wicker the Army's promotion paths to facilitate the rise of aviators. In fact, the opposite was true. The Army's promotion system severely penalized aviation officers and failed to promote them at anywhere near the rate at which it promoted their peers who served in more traditional combat branches like the infantry and armor. Aviators achieved promotional parity only in the 1990s, more than three decades after helicopters experienced rapid growth.[528] Aviation became a combat branch within the

[525] Ibid.
[526] Rosen declares, "The control of the promotion of officers is the source of power in the military" [Ibid, 20].
[527] Ibid, 105.
[528] In 1978 and 1979, then Chief of Staff of the Army General Bernard Rogers solicited the advice of his peers about whether aviation should be made a combat branch of the army. "He sent back channel messages to all of his four star generals to get their opinions of the concept. *Not a single four star officer supported the idea*. Only two

Army on April 12, 1983. Prior to that, aviation was treated as a specialization rather than a career. The establishment of Aviation as a combat branch and the subsequent adoption of a new aviation force structure finally afforded aviation officers with sufficient command opportunities to ensure career viability, but there was a transition period of approximately ten years when aviators continued to underperform other branches at promotion boards.[529]

Third, the Army chooses to staff its helicopters in a manner antithetical to Rosen's hypothesis. A large percentage of Army aviators are warrant officers, not line officers. Employing warrant officers instead of line officers to fly helicopters dilutes the power of the rotary-wing constituency within the Army.[530] Warrant officers are technical specialists who are not eligible to rise through the ranks, something Rosen proclaims is required to secure innovation.[531]

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acknowledged that a day may eventually come when a branch would be necessary. The rest of the four stars were *strongly opposed*" (emphasis added) [Frank W. Tate, "Army Aviation as a Branch, Eighteen Years After the Decision," School of Advanced Military Studies Monograph, 2000, 25]. This anecdote is insightful because it highlights the fact that aviators had yet to penetrate the inner-circle of Army leadership decades *after* the adoption of helicopters within the Army. No aviator has ever been selected to lead the Army. Since 1947 (i.e., the Army's split with the Air Force), the Army has promoted only one aviator to four-star rank.

529 Frank W. Tate, "Army Aviation as a Branch, Eighteen Years After the Decision," School of Advanced Military Studies Monograph, 2000, 47. The following passage highlights how career concerns for aviators, even after Aviation became a branch, was a source of great dissatisfaction: "Aviators were given mixed messages by the Army as to what was important and what they should do to best serve the Army and have a successful career. Aviators at this time had a ground basic branch and an aviation specialty. They competed for promotion against other members of their basic branch. This meant that they needed command and high-level staff positions within their basic branches but they were often denied those positions because they were aviators. Congress had mandated strict limits on the amount of time aviation qualified officers could spend away from aviation assignments because of costs. This indicated that service in aviation jobs was important yet for promotion they needed jobs in their basic branch … [Officers] seemed to be 'marking time' [in Aviation positions] while they waited for an assignment back to their basic branch that would help their careers" [Ibid, 33-34].

530 In 1956, the Army converted more than one third of its 3,190 aviator billets into warrant officer positions [Richard P. Weinert, *History of Army Aviation 1950-1962, Phase II: 1955-1962* (Fort Monroe, VA: Historical Office of the Chief of Staff, U.S. Army Training and Doctrine Command, November 1976), 22].

531 Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 20.

The New, Cross-Disciplinary Framework Adds Value

Historical evidence from this case suggests the new, cross-disciplinary framework adds explanatory power. Answering the set of questions posed in the "Research Approach" section of Chapter 1, the following discussion summarizes that evidence.[532]

First, do changes in a state's security situation and interservice competition, the two factors identified in doctrinal innovation literature as drivers of innovation, sufficiently explain when and why the U.S. military adopted the helicopter? Or, per this dissertation's central hypothesis, did the perceived attributes of the helicopter also weigh heavily in leaders' decisions?

The perceived attributes of the helicopter appear to have weighed heavily in its development and adoption, more so than changes in the nation's security situation and interservice competition. Compatibility, one of the four perceived attributes identified in this study as influential, explains much of the reason why the Air Force lacked interest in the helicopter and why the Army embraced it. For the Air Force, particularly from the perspective of the "bomber mafia," the service's dominant subculture for nearly thirty years, rotary-wing aviation was incompatible with the service's past experiences and its primary mission: strategic bombing. Manned bombers had brought victory in World War II; now, they could fly higher, faster, and farther to deliver a destructive power that far exceeded any in history.[533] Embracing

[532] The questions highlight key differences between Posen, Rosen, and Coté theories and the new, cross-disciplinary model proposed in this study.
[533] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 133.

low-and-slow helicopters would have kept Air Force pilots close to the battlefield and in support of the Army, the last place they wanted to be.[534] As a result, bomber generals funneled the vast majority of Air Force research-and-development funds (R&D) into programs to build bigger, faster, and higher-flying nuclear bombers like the XB-70 Valkyrie, a supersonic plane designed to fly in the stratosphere at more than three times the speed of sound. Progress was measured in terms of range, speed, and altitude—the exact opposite of the aircraft characteristics favored by the Army.[535] Whereas the Air Force wanted higher, faster, farther, the Army preferred lower, slower, and closer. Needless to say, the Army perceived the Air Force's focus on building nuclear bombers as being incompatible with the airpower priorities of the senior service. Nuclear bombers were worthless in performing close air support.

As a result, the Army found itself in a difficult situation. With the split between the Army and Air Force in 1947, the Army was dependent on the Air Force for its air support, but the Air Force considered the Army a secondary customer and, frankly, was not interested in developing aircraft to support the senior service.[536] To quote one Army officer, "The Air Force was 'above it all.' It had abandoned the battlefield in favor of the 'wild blue yonder,' leaving the Army naked and unsupported."[537] The helicopter offered the Army a "good enough" capability and an opportunity to rebuild its organic airpower capability. In some respects, particularly as technology advanced, the helicopter provides a better match than fixed-wing

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[534] The Air Force adopted relatively few helicopters. It principally used the helicopters it did buy for search and rescue, a mission supporting its fleet of manned fixed-wing aircraft.
[535] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 371.
[536] The U.S. Marine Corps and U.S. Navy, because they retained their air arms, did not have the same problem as the Army.
[537] Frank W. Tate, "Army Aviation as a Branch, Eighteen Years After the Decision," School of Advanced Military Studies Monograph, 2000, 7.

aviation for the Army's airpower requirements.[538] Besides, bureaucratic restrictions prevented the Army from adopting manned fixed-wing aircraft, so the choice was really between continuing to rely on the Air Force for air support, an option Army leaders were dissatisfied with, or adopting the new class of weapon. Unlike the situation in the Air Force, although there was some internal resistance to adopting the helicopter from conservative officers, the idea enjoyed considerable support among senior leaders because it reinforced rather than undercut the dominant subcultures within the U.S. Army, the infantry and armor. The helicopter gave them more mobility and firepower support.

The helicopter cut its teeth during the Korean War, an opportune trial-by-fire showcasing its promise and improving trialability and observability. Nevertheless, the opportunity to experiment with the helicopter on a limited basis highlighted performance limitations of early rotary-wing aircraft. Korean War-era choppers could barely pick themselves off the ground on a warm day. Technological immaturity, in the words of U.S. Army's Aviation Branch historian, "delayed the full impact of this aircraft's versatility until late in the 1950s."[539] The development of the turbine engine, a technological breakthrough that vastly improved performance, allowed helicopters to expand beyond performing niche roles such as medical evacuation, reconnaissance, and VIP transport. Turbine-powered helicopters provided considerable more lifting power than piston-powered choppers, which greatly expanded the range of missions they could accomplish and thus, greatly improved the relative advantage offered by the helicopter. The timing of the development of the turbine engine and the

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[538] Although they lacked speed and survivability, helicopters at least stayed close to the front lines.
[539] Richard P. Weinert, *History of Army Aviation 1950-1962, Phase II: 1955-1962* (Fort Monroe, VA: Historical Office of the Chief of Staff, U.S. Army Training and Doctrine Command, November 1976), 1.

delivery of the Army's first Huey were fortuitous; the onset of the Vietnam War, another conflict in which helicopters were tried and tested in battle, served to accelerate their growth.

No doubt, the wars in Korea and Vietnam as well as other changes in the state's security situation influenced and accelerated the U.S. Army's adoption of the helicopter. It seems a stretch, however, to attribute the Army's adoption of the helicopter, as Stephen Rosen does, to the advent of nuclear weapons and ballistic missiles.[540] Rosen credits James Gavin with anticipating how nuclear weapons and ballistic missiles, years before they became a reality, would give the enemy more firepower. Gavin reasoned that increased enemy firepower would require U.S. ground forces to disperse since massed troops would provide lucrative targets on a nuclear battlefield. Thus, Rosen suggests this made the helicopter attractive because the technology provided mobility on the battlefield, enabling commanders to keep troops dispersed, yet quickly mass them when needed. Gavin did, in fact, write an article in 1954 that garnered attention in which he advocated for using not just helicopters, but light aircraft as well to improve mobility, but as stated earlier, the Army's interest in helicopters began years earlier.[541] In 1950, the Army Chief of Staff Joseph Lawton Collins requested that the Secretary of Defense lift restrictions so the Army could purchase a fleet of helicopters for combat in Korea. By the time Gavin wrote his article, the Army already owned more than a thousand whirly birds, and helicopters were firmly established on an exponential growth trajectory that continued through the 1960s. Later in his book, Rosen attributes the Army's adoption of the helicopter to the Howze Board's identification in 1962 of a general trend toward high-accuracy

[540] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 72. Note: tactical nuclear weapons were development and deployment in the late 1950s and early 1960s.
[541] James M. Gavin, "Cavalry, and I Don't Mean Horses," *Harper's Magazine*, April 1954, 54-60, available at http://www.combatreform.org/cavalryandidontmeanhorses.htm.

missiles, chemical and biological weapons, and improved nonnuclear weapons.[542] By that time, however, the Army had amassed more than 4,000 helicopters. In summary, changes in the nation's security situation reinforced the Army's interest in the helicopter, but they were not the underlying source.

The Army's interest in the helicopter was also not spurred by competition from the Air Force. Far from competing with the Army to adopt the helicopter, the Air Force shunned the helicopter. Furthermore, the service fought for decades to preserve and enforce bureaucratic restrictions designed to stifle competition and prevent the Army from rebuilding its organic air forces. Until the service finally acceded in the 1970s, the Air Force actions impeded, rather than facilitated the Army's adoption of the helicopter.

Second, was interservice competition, as Coté alleges, overwhelmingly a function of "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services"?[543] *Or, did the perceived attributes of the helicopter also influence competitive and cooperative patterns of service behavior?*

Historical evidence suggests competitive and cooperative patterns of service behavior are not just a function of "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services"[544] In this case, the perceived attributes of the helicopter also played a role in whether and when interservice competition emerged.

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[542] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 73.
[543] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 351. See also p. 339-340.
[544] Ibid.

The Air Force was not interested in and did not compete to adopt the helicopter because it viewed the new class of weapon as incompatible with its operations. Moreover, the Air Force perceived the relative advantage offered by its fixed-wing force to dwarf that offered by the helicopter. In the only mission area where the two services competed—the competition between the Cheyenne and the A-10—the Air Force met the challenge by offering a fixed-wing alternative.

In contrast to the Air Force, the Army favorably viewed the attributes of the helicopter and sought to capitalize on them. Since helicopter technology blurred previously defined roles-and-missions boundaries, it used rotary-wing aircraft to nibble away at geographic, weight, and functional restrictions that had prevented it from rebuilding its organic air forces. The development of the turbine engine allowed the helicopter to expand beyond niche roles and to assume core mobility and firepower functions within the Army.

In short, the perceived attributes of the helicopter influenced the competitive and cooperative patterns of service behavior.

Third, is the pace of innovation binary? In other words, does it occur at one of two speeds: fast or slow? Or, does it tend to occur commensurate with the rate at which relative advantage evolves?

The helicopter appears to have followed a path of adoption that that Clayton Christensen suggests is common for disruptive innovations; it first gained a foothold performing peripheral roles (e.g., medevac, search and rescue, reconnaissance, etc.) and then blossomed

over time to assume core mobility and firepower functions within the Army. This march "up market" did not occur at a single speed, but accelerated commensurate with the evolution of relative advantage offered by the helicopter. The development of the turbine engine boosted the relative advantaged offered by the helicopter, allowing it to graduate to core combat missions. As the new class of weapon passed into general use, it attracted more investment, which, in turn, helped accelerate technological advances that improved helicopter performance and relative advantage.

Fourth, did civilians or military leaders drive weapon system innovation, or were both civilians and uniformed leaders influential?

This chapter chronicles how a succession of Army leaders supported the adoption of the helicopter. This included six chiefs of staff: Joseph Lawton Collins, Matthew Ridgway, Maxwell Taylor, Lyman Lemnitzer, George Decker, and Harold Johnson. Other high-ranking uniformed officers, such as James Gavin and Hamilton Howze, also championed the idea. Although the adoption of the helicopter was largely driven by those in uniform, civilians, including President John F. Kennedy and Secretary of Defense Robert McNamara, among others, helped accelerate the helicopter's adoption. Thus, both military officers and civilians were influential.

The next chapter continues exploring post-World War II airpower-related weapon system innovation, investigating the adoption of the unmanned aircraft.

CHAPTER 5

UNMANNED AIRCRAFT

"This is an inflection point … The trend lines are unmistakable that the United States Air Force will be an increasingly unmanned aviation service."[545]

— *General Norton A. Schwartz, U.S. Air Force Chief of Staff*

This chapter investigates the adoption of unmanned aircraft. First, it presents a historical narrative discussing events and factors that stimulated the U.S. Air Force and U.S. Army to adopt the unmanned aerial vehicle (UAV).[546] Next, it compares the explanatory power of Owen Coté, Barry Posen, and Stephen Rosen's theories with that offered by the new, cross-disciplinary framework proposed in this study. The case reveals that the latter adds value.

UAV HISTORY

Ripe Conditions for the Adoption of the UAV

The historical narrative in this section is very much a continuation of those presented in the previous two chapters. The "bomber mafia," the dominant subculture within the Air Force

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545 Statement of General Norton A. Schwartz, Chief of Staff, U.S. Air Force, in Senate, Committee on Armed Services, *Hearing to Receive Testimony on the Department of the Air Force in Review of the Defense Authorization Request for Fiscal year 2010 and the Future Years Defense Program*, 21 May 2009, 11, http://armed-services.senate.gov/Transcripts/2009/05%20May/09-35%20-%205-21-09.pdf.

546 This chapter does not address U.S. Navy and Marine Corps UAV efforts because they are, to quote a Navy Studies Board report, "significantly behind the other services in numbers and in fielding modern [UAV] systems" [Navy Studies Board, Committee on Autonomous Vehicles in Support of Naval Operations, *Autonomous Vehicles in Support of Naval Operations* (Washington, DC: National Academies Press, 2005), 106]. The 2005 report proclaimed, "Absent a dramatically increased involvement with UAVs, the Navy and Marine Corps run the risk of falling farther behind, not fully exploiting the benefits offered by Army and Air Force systems, and lagging in efforts to shape the direction that new UAVs systems will take in the future" [Ibid, 108]. Since the report was issued, the Navy has made some progress. For example, it deployed a limited number of ScanEagles on its ships. Additionally, it is planning sea trials for the X-47B, an Unmanned Combat Aerial Vehicle demonstrator, in 2013. Nevertheless, the Navy and Marine Corps remain significantly behind the other services in the development and adoption of unmanned aircraft.

for more than thirty years, developed spectacularly complex and expensive planes that were incompatible with the Army's airpower needs.[547] The Army, which was (1) dependent on the Air Force for its airpower, (2) not served well by the Air Force's sustaining innovations, and (3) prevented from developing its own fixed-wing aircraft due to bureaucratic barriers, adopted rotary-wing aircraft to better meet its needs (see Chapter 4). Nevertheless, for a variety of reasons, the helicopter has not entirely satisfied the Army's airpower requirements and thus the story continues.[548]

This narrative picks up the story with the B-2 Spirit, the swan song of the bomber mafia. The B-2 program originated in 1979, a few years before bomber pilots' reign as the dominant subculture within the Air Force came to an end. The advanced bomber was designed during the height of the Cold War to penetrate the Soviet Union's tight web of integrated air defense systems and loiter undetected while searching for mobile, multiple-independently-targetable-reentry-vehicle (MIRV) missiles. To perform that demanding, high-end mission, engineers pushed the envelope of what was technically feasible, designing the aircraft with features that made it extravagantly expensive. In fact, it is the most expensive aircraft ever built. At $2.13 billion, each bomber cost more than the defense budgets of most countries.[549] The B-2

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[547] For example, the B-70, a 250-ton, six-jet delta-wing, nuclear bomber was designed to fly at more than 2,000 miles per hour, faster than the earth's rotation, while carrying an atomic payload equivalent to almost a 4,000-mile trainload of TNT.

[548] Helicopters, for example, are extremely vulnerable. The U.S. Army lost nearly 5,000 helicopters in the Vietnam War, mostly to small arms and machine guns. As one news report notes, "Technological developments since then have made flying combat helicopter missions somewhat safer, but it will always be dangerous sending such slow, low-flying aircraft into hostile situations" ["Iraq: Crashes, Collisions Call Into Question Vulnerability Of Helicopters In Battle," 25 March 2003, http://www.defense-aerospace.com/article-view/feature/18891/iraq%3A-helicopter-vulnerability-questioned.html].

[549] Source of the $2.13 billion cost figure: the U.S Air Force's B-2 Program Office [see General Accounting Office, "B-2 Bomber: Cost and Operational Issues" (Letter Report, 08/14/97, GAO/NSIAD-91-181), available at http://www.fas.org/man/gao/nsiad97181.htm]. When built, the cost of one bomber exceeded the defense budgets of Sri Lanka, Ecuador, Indonesia, and Brazil, among others [George and Meredith Friedman, *The Future of War: Power, Technology & American World Dominance in the 21st Century* (New York, NY: Crown Publishers, 1996),

program is so expensive that the Air Force, borrowing from the Navy's practice of naming its capital ships, gave each B-2 bomber in its inventory an official name (e.g., *Spirit of America* and the *Spirit of Kansas*).[550] The Air Force originally wanted a force of 132 B-2s, but ended up acquiring only twenty-one, in large part because of the exorbitant cost of producing and maintaining each aircraft.[551] Although the B-2 is a technological marvel which fulfills the aspirations of bomber advocates, when engaged in anything less than its high-end nuclear penetration mission, the Spirit vastly over-delivers capability.

A large disconnect exists between the capabilities that the bomber delivers and what the Army demands. The Army, organized around the conduct of land warfare, is more concerned with ground-centric airpower missions, such as tactical reconnaissance and close air support, than strategic bombing, which strikes targets thousands of miles away from the front lines. As a result, the B-2, from an Army perspective, offers unneeded and expensive high-performance capability.[552]

298]. Note: a list that shows the military expenditure of each country of the world is available at http://milexdata.sipri.org.

[550] It is not surprising that the Air Force borrowed the Navy's tradition because the $2.13 billion price tag of the B-2 is about twice as expensive as a guided-missile destroyer ($1.15 billion) and nearly as expensive as a nuclear attack submarine ($2.43 billion) [reference Table 1.1 on page 2 of the Rand publication *Why Has the Cost of Navy Ships Risen?* available at http://www.rand.org/pubs/monographs/2006/RAND_MG484.pdf]

[551] Each hour of B-2 flight necessitates 119 hours of maintenance, principally to preserve and fix its low-observable, stealthy skin. To facilitate this extensive maintenance program, the Air Force built massive air-conditioned hangars large enough to accommodate the bomber's 172-foot wingspan ["The Gold Plated Hanger Queen Survives," http://www.strategypage.com/htmw/htairfo/articles/20100614.aspx].

[552] For example, there is simply no need for the advanced bomber's stealthy characteristics when flying missions in the permissive skies of Iraq and Afghanistan. Insurgents in Iraq and Afghanistan do not possess defensive means which require Americans to use the stealth bomber. In fact, they have no medium and high-altitude, anti-aircraft capability. Although the B-2 is certainly capable of loitering over an Army platoon for hours watching the perimeter of a remote outpost or using its targeting pod to search ahead of a convoy's intended route of travel for improvised explosive devices, other types of aircraft can do the job at pennies on the dollar. Using the advanced bomber in any of the aforementioned missions, particularly on a recurring basis, is prohibitively expensive. Additionally, since there are less than two dozen B-2s in the Air Force's inventory, even if all are assigned to support small Army units, there still would be a plethora of unsatisfied Army demands for airpower support.

The B-2 was the bomber mafia's last hurrah. A changing of the guard within the U.S. Air Force occurred in 1982 when General Charles Gabriel, a fighter pilot, was appointed chief of staff.[553] Fighter pilots wrested institutional leadership away from the bombing community after the adoption of the intercontinental ballistic missiles (see Chapter 3) decimated the service's bomber force. By 1982, the number of bombers in the Air Force's inventory had dropped 84 percent, from a post-World War II peak of nearly 2,500 to a relatively miniscule 391 bombers.[554]

Not surprisingly, when fighter pilots gained power, they advocated for more and better fighters. By 1985, the "fighter mafia" had scored a large increase in the active-duty fighter inventory, from a post-Vietnam low of 2,299 aircraft to approximately 4,000.[555] The Air Force's shift from nuclear bombers to fighters, however, did little to alleviate the Army's discontent over its airpower support.[556] With one exception, the fighter-pilot-dominated Air Force leadership developed fighters optimized for air-to-air combat, not close air support. The one exception was the A-10 Thunderbolt, a dedicated ground-attack aircraft, which the Air Force begrudgingly bought during the post-Vietnam fighter build-up. It did so after feeling threatened by the Army's attempt to acquire the Cheyenne attack helicopter, which Air Force

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553 General Charles Gabriel was the first in an unbroken string of nine fighter pilots to serve as chief. The string was broken in 2008 with the firing of General T. Michael Moseley and the appointment of General Norton Schwartz.

554 Source for aircraft inventory numbers: James C. Ruehrmund, Jr. and Christopher J. Bowie, *Arsenal of Airpower: USAF Aircraft Inventory 1950-2009* (Arlington, VA: Mitchell Institute Press, 2010).

555 Ibid. For use of the term "fighter mafia," see, for example, Julie Bird, "Fighter Mafia Taking Over," *Air Force Times*, 1 February 1993, 12–13. See also Julian E. Barnes and Peter Spiegel, "A Different Type of Air Force Leader," *Los Angeles Times*, 10 June 2008, available at http://articles.latimes.com/2008/jun/10/nation/na-schwartz10.

556 Although air-superiority fighters facilitate the accomplishment ground-centric airpower missions like close air support and they protect ground personnel from enemy air attacks, the Army takes air superiority for granted because the United States has enjoyed it in every conflict the United States has fought since World War II. The last time the United States lost a soldier to an enemy air attack was during the Korean War during the 1950s [Tom Engelhardt, "What U.S. Air Power Actually Does," 18 March 2011, http://www.cbsnews.com/stories/2011/03/18/opinion/main20044539.shtml].

leaders thought encroached upon their service's roles and responsibilities.[557] Nevertheless, the A-10's contribution to fulfilling the Army's airpower requirements was, to a certain extent, offset by the Air Force sending the service's fleet of RF-4C Phantoms, a version of the F-4 whose mission was to provide reconnaissance, into retirement in the early 1980s without a replacement.

After assuming the leadership reins of the Air Force, fighter generals proceeded to develop the world's most advanced air-to-air fighters, culminating in the development of the F-22 Raptor.[558] The Raptor, a stealth fighter that can "supercruise," which means it has the ability to fly faster than the speed of sound without the use of afterburners, is the world's only combat-ready fifth-generation fighter. Similar to how the B-2 was the zenith of bomber pilots' aspirations, the Raptor is truly a dream come true for fighter pilots. When establishing the original requirements for the F-22, the fighter-pilot-dominated Air Force leadership requested bids for a specialized aircraft that just shot down other aircraft, not one designed for what it viewed as the lesser task of striking targets on the ground. Air Force leadership even invented a new marketing term for the aircraft, calling the Raptor the world's only "air dominance" fighter.[559]

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[557] See Chapter 4.

[558] With its origins in the early 1980s, the F-22 is a Cold War product designed to shoot down the Soviet Union's most advanced aircraft.

[559] Testifying before the Senate Armed Services Committee on March 14, 1996, Ron Fogleman made the following pitch: "I would describe the difference between 'air dominance' and 'air superiority' as one of magnitude of ability to influence events in a given piece of airspace. For instance, when you begin to conduct any kind of a combat or theater-wide operation, normally that theater commander's first priority is to make sure that you have air superiority over your own troops, [which should] generally guarantee that you will not have your troops attacked. . . . The next stage has been called air supremacy, where you, for all intents and purposes, not only are able to defend your own people, but you pretty much dominate the space. You can operate at will in there. Air dominance . . . is a term that's sort of grown up in the last couple of years in joint doctrine. … Dominance to me is kind of an extension of the supremacy idea that says, 'Nothing moves or operates in that guy's airspace.' I mean, you totally control it. It's a step above" [Quoted in "Verbatim," *Air Force Magazine*, August 1996, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1996/August%201996/0896verb.aspx].

The F-22 would have stayed an air-to-air-only fighter, except it ran into funding difficulties due to the jet's enormous cost, which was as staggering as its performance. At more than $361 million each, the Raptor is an order of magnitude more expensive than the $35 million unit cost of the F-15 Eagle, the aircraft it was supposed to replace.[560] Although the Air Force wanted 750 Raptors, exorbitant unit costs drove mounting opposition to the specialized aircraft. In a transparent political effort to broaden the Raptor's appeal, fight pilots who ran the Air Force clenched their teeth and permitted a design change to give the F-22 limited air-to-ground capability.[561] The attempt to broaden the F-22's appeal, however, yielded little in the way of additional political support for the aircraft. As a result, Secretary of Defense Robert Gates, despite vehement protests from the Air Force, reduced the Raptor buy and eventually terminated production in 2009 after Lockheed, the jet's manufacturer, delivered 187 aircraft.[562]

Why did the Raptor cost so much? Defense analysts attribute the exponential cost increase in fighter aircraft over the last four decades to complexity of design.[563] Figure 11 provides a detailed breakdown of the factors contributing to the escalating cost of fighter aircraft from 1975 to 2005; the graph captures the transition from fourth generation aircraft like the F-15 and F-16 to the F-22. Not only did "technical complexity," the product of pursuing

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[560] The Government Accountability Office lists the Raptor's program unit cost as $361 million [Government Accountability Office, "Defense Acquisitions: Assessments of Selected Major Weapon Programs" (GAO-06-391), March 2006, 67 available at http://www.gao.gov/new.items/d06391.pdf]. The U.S. Air Force lists the jet's price tag as $143M, but that figure represents the "flyaway cost," what it would cost to acquire each additional aircraft if the production was not curtailed [U.S. Air Force, "F-22 Fact Sheet," available at http://www.af.mil/information/factsheets/factsheet.asp?id=199].

[561] In September 2002, Air Force leaders changed the Raptor's designation from the F-22 to F/A-22. Note: the "A" designation stands for "attack. The nomenclature change was intended to highlight plans to give the jet a limited ground-attack capability amid an intense debate over the relevance of the expensive air-to-air-only fighter jets. After the transparent political attempt to market the Raptor as a multi-role fighter yielded little in the way of additional support for the aircraft, Air Force leaders changed the jet's nomenclature back to the F-22 when the fighter entered operational service in December 2005.

[562] The Air Force leadership, not getting the numbers of Raptors it wanted, delayed the retirement of the F-15.

[563] See chapter 2 for a discussion of how *cost* and *complexity* feed off each other in a vicious, reinforcing cycle.

lighter airframe material, faster maximum speed, and greater stealth capability, serve as the largest driver of higher costs, but it contributed more than all the other factors combined.[564]

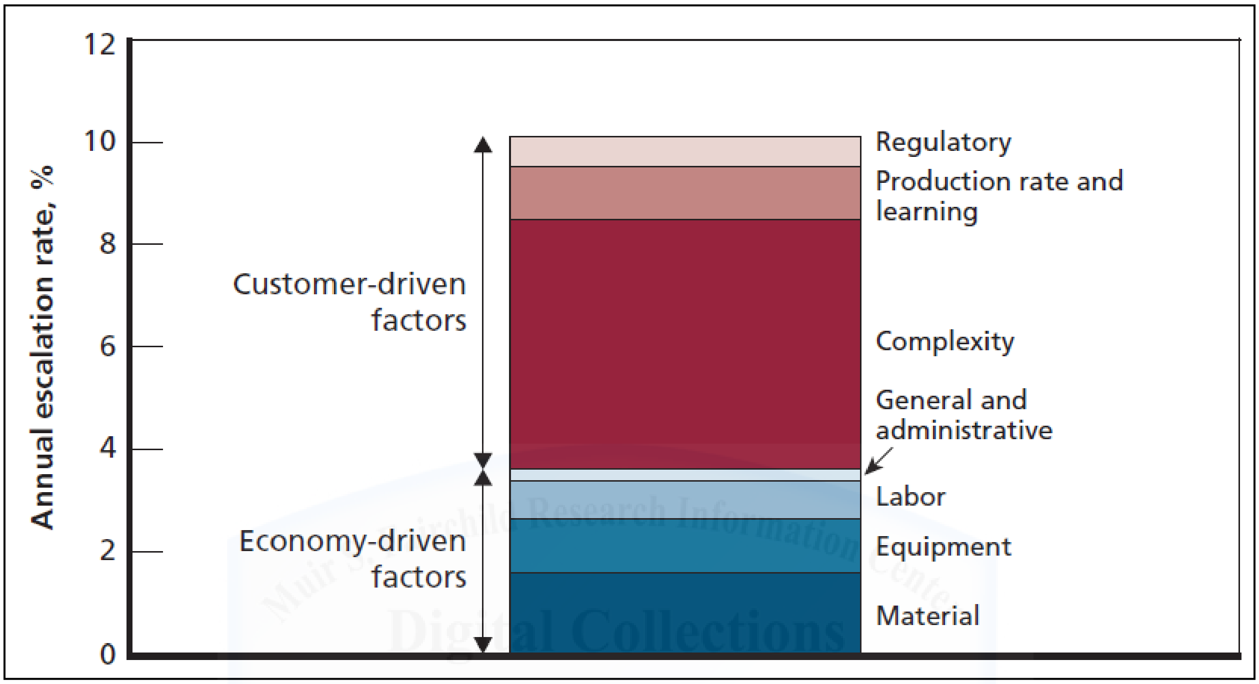

FIGURE 11 – Factors That Have Contributed to Cost Increases in Fighter Aircraft (1975 – 2005)[565]

The Raptor's complex design meant an exceptionally long production timeline.[566] The Air Force had developed the requirement in the early 1980s for a new air-superiority fighter, calling it the Advanced Tactical Fighter (ATF). The service issued a request for proposal (RFP) in

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564 "Cost Controls: How Government Can Get More Bang for Its Buck," *Rand Review*, Spring 2009, http://www.rand.org/publications/randreview/issues/spring2009/cost3.html

565 Mark V. Arena, et al, "Why Has the Cost of Fixed-Wing Aircraft Risen? A macroscopic Examination of the Trends in U.S. Military Aircraft Costs over the Past Several Decades," Rand report prepared for the U.S. Navy and U.S. Air Force, 2006, xvii, available at http://www.rand.org/content/dam/rand/pubs/monographs/2008/RAND_MG696.pdf.

566 Every generation has experienced longer development times.

1986, but needed a 50-month design and flight-test competition to assess competing complex designs. The first F-22s were delivered in 2002, twelve years after competition results were announced. It took several more years before the system was finally deemed operational. All told, it took more than two decades to develop the F-22. By way of comparison, the F-104 Starfighter, a second-generation fighter, took five years. Indeed, putting a man on the moon took about half the time it took to design, build, and deliver operational F-22s.[567] The Raptor took so long to produce that many of its parts suffered obsolescence before the first aircraft rolled off the assembly line.[568] For example, the F-22's avionics system underwent four "technology refresh cycles" before the first production aircraft was delivered to the Air Force.[569]

Similar to the bomber community's experience with aircraft like the XB-70 and B-2, fighter pilots' perennial pursuit of ever-more-perfected fighters paradoxically resulted in less, not more, efficient weapons. "There is no doubt the F-22 has unique capabilities that we need," Robert Gates noted in his explanation to Congress why he was curtailing the Raptor program and ending production. "But the F-22 is, in effect, a niche, silver-bullet solution required for a limited number of scenarios to overcome advanced enemy fighters and air defense systems."[570] While even the B-2 participated, in a limited role, in the wars in Iraq and

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[567] It took eight years from when President John F. Kennedy said "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth" until Neil Armstrong became the first man to set foot on the Moon [Deloitte Consulting, "Can we afford our own future? Why A&D programs are late and over-budget and what can be done to fix the problem," 2009, 6].
[568] "Obsolete Parts Plague F-22 Before First Flight," *Janes Defence Weekly*, 13 August 1997, available at http://articles.janes.com/articles/Janes-Defence-Weekly-97/OBSOLETE-PARTS-PLAGUE-F-22-BEFORE-FIRST-FLIGHT.html.
[569] Roxana Tiron, "Aging Avionics Spell Doom for Air Force, Study Warns," *National Defense,* Vol. 86, No. 573, August 2001, 26.
[570] Rebecca Grant, "The Evolution of Airpower Under Gates," *Air Force Magazine*, February 2011, 57.

Afghanistan, the F-22 has yet to fly a single sortie in any armed conflict since it became operational in 2005.[571]

Ripe Conditions, But Technological Immaturity Inhibited Growth

Despite ripe conditions, technological immaturity meant unmanned aircraft were poor investments prior to a confluence of certain enabling technologies that occurred in the 1990s. As a result, unmanned aircraft foundered until the introduction of the Predator, the breakout UAV that launched the apparent on-going revolution in airpower.[572] Although the U.S. military pursued approximately two dozen unmanned aircraft programs before the Predator, to quote Thomas Ehrhard, "*In every case*, they fell below the threshold from which they could be pulled up to an operational configuration by an aggressive development program" (emphasis added).[573]

[571] The F-22 also failed to play a role in our nation's most recent military engagement, enforcing a no-fly zone over Libya. An Air Force spokesman suggested, "Because of the speed upon which the operations came together with our coalition partners, [the joint task force] needed to look realistically at the fighter assets already within Europe to execute operations" [Dave Majumdar and Scott Fontaine, "Conspicuously Absent: Why The Raptor Sat Out the Air War Over Libya," *Air Force Times*, 4 April 2011, 20]. The implication was that the F-22 was not used because it was not stationed in Europe. The Air Force, however, deployed other assets from outside of Europe to support the operation. Moreover, Michael Shower, a retired Air Force lieutenant colonel who was among the original F-22 test pilots and one of the first to command a Raptor squadron, said the Air Force spokesman's argument was "not credible." He continued: "We sell ourselves as a deployable force and as a global-strike force. We've done missions where we've flown eight hours to go into an area and escort B-2s into a combat mission. To say that we didn't … have time is a bunch of baloney. We tell the public, 'We're deployable in 48 to 72 hours.' Well, they knew this was coming for weeks." Shower said not using the Raptor in Libya raises questions about why the U.S. bought the plane in the first place. "We needed to launch these Tomahawks [cruise missiles] to degrade the defenses so we could get the aircraft in," Shower said. "But that's exactly why we told the public we had to spend $50 billion for the F-22: to kick down the door in those high-threat areas so they can engage these high-value targets" [Ibid]. Mark Gunzinger, an analyst with the Center for Strategic and Budgetary Analysis in Washington, stated, "Frankly, they might not be needed. Libya's defenses were not that robust to begin with and were rolled back quite handily" [Ibid]. Marvin Sambur, a former Air Force procurement chief, said, "The [Raptor's] air-to-ground capability is lagging, and is probably lagging more than the Air Force has ever wanted to admit because of the computer architecture. The F-22 is not ready to do it" [Ibid]. Note: it has been six years since the aircraft was deemed "operational."

[572] Thomas Ehrhard, *Air Force UAVs: The Secret History* (Arlington, VA: Mitchell Institute Press, 2010), 38.

[573] Ibid, 43.

Rather than describe the specific shortcomings of every unmanned aircraft prior to the Predator, the next two sub-sections chronicle the fate of two—the Air Force's Lightning Bug (see Figure 12) in the 1970s and the Army's Aquila (see Figure 13) in the 1980s. Outlining the reasons for failure of these two programs is informative because it frames the technological challenges that the Predator had to overcome in order to go "viral." The Lightning Bug represents somewhat of a "toughest test case" for the assertion that technological immaturity was the principle reason why unmanned aircraft foundered despite ripe conditions because the drone showed the most promise of any prior to the Predator.[574] The U.S. Air Force operated the Lightning Bug for more than a decade, launching 1,016 drones on 3,450 reconnaissance sorties during the Vietnam War.[575] Hence, if any unmanned aircraft prior to the Predator was likely to push the technology beyond a tipping point, it would have been the Lightning Bug. Instead of igniting an unmanned revolution, however, its limited value relative to other platforms led to its cancellation shortly after the Vietnam War.

Unlike the Lightning Bug, the Army's Aquila never made it beyond the testing stage of development. Aquila was a complete technological failure; the program collapsed of its own weight after new features were added to the specification in an undisciplined fashion. Because there was no clear organizational owner for the project within the Army, various branches kept piling on requirements until it became technologically impossible given the capabilities of the day.[576] The Aquila is notable because the Army invested $1 billion in the program before it was

[574] Alexander L. George and Andrew Bennett, *Case Studies and Theory Development in the Social Sciences* (Cambridge, MA: Harvard University Press, 2004), 123.
[575] The Lightning Bug also flew a handful of reconnaissance missions over China.
[576] "The program still remains a source of embarrassment to those who were involved in it" ["Unmanned Aircraft: US Battlefield UAVs," http://www.vectorsite.net/twuav_07.html].

cancelled.[577] The colossal failure led Congress to intervene in UAV acquisition through the creation of the Defense Airborne Reconnaissance Office (DARO), taking funding and management discretion away from the armed services for nearly a decade.

FIGURE 12 – The Ryan Model 147B Lightning Bug[578]

[577] The program did not fail because of a lack of funding.
[578] Source: http://www.blackbirds.net/uav/bixbydrones/page-2.html. The photograph shows a Lightning Bug being carried on the pylon of a C-130. The Lightning Bug was a jet aircraft with a 27-foot wingspan capable of flying just below the sound barrier at altitudes up to approximately 50,000 feet.

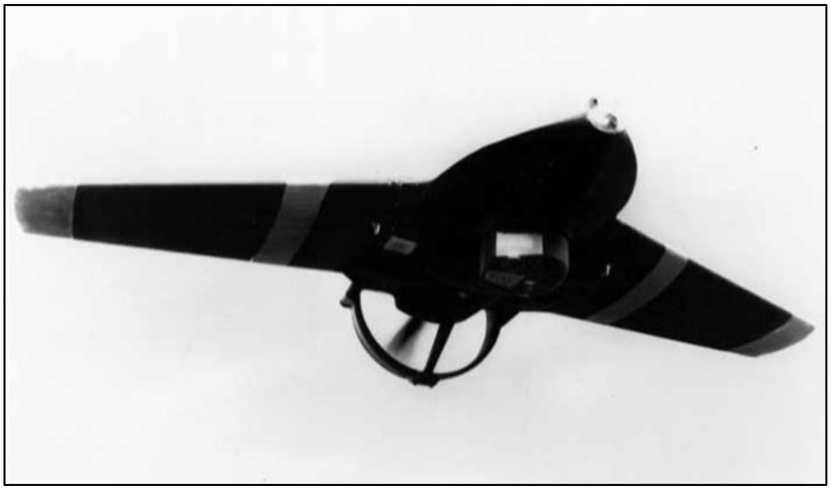

FIGURE 13 – The MQM-105 Aquila[579]

The Air Force's Lightning Bug

The Lightning Bug was cancelled because the cost of the program far outweighed its military effectiveness compared with existing alternatives.[580] The drone never came close to the mission effectiveness rate of manned reconnaissance aircraft. In 1971, six years after the Lightning Bug first started flying over Vietnam, well down the "learning curve," it was able to achieve only a dismal 40% mission effectiveness rate.[581] In comparison, manned tactical reconnaissance aircraft enjoyed a 70% mission success rate.[582]

The Lightning Bug's mission-effectiveness problems stemmed from three issues: (1) an inaccurate navigational system, (2) complex takeoff and recovery systems, and (3) a relatively

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[579] Source: Redstone Arsenal (also available at http://www.militaryfactory.com/aircraft/detail.asp?aircraft_id=376). The Aquila had a wingspan of a little over twelve feet. It was powered by a piston engine that could propel it to a maximum speed of 130 miles per hour and a service ceiling of 14,800 feet.

[580] "The cost of the Lightning Bug program far outweighed its military effectiveness ... [the] technology simply failed to support its experiment" [Thomas Ehrhard, *Air Force UAVs: The Secret History* (Arlington, VA: Mitchell Institute Press, 2010), 45].

[581] Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture," School of Advanced Air and Space Studies Monograph, June 2007, 12.

[582] Ibid.

long delay in processing any intelligence information gathered.[583] In an era before the Global Positioning System (GPS), a constellation of satellites that enables precise navigation, the Lightning Bug relied on internal gyros to calculate its position. Its internal gyros, however, did not work very well, and the drone's navigational system drifted by as much as three percent of the distance flown.[584] If the Lightning Bug had to fly 100 miles to reach its target, the drone might end up offset from its intended route of flight by as much as three miles. For high-altitude missions, a navigational error of that magnitude did not matter that much because the wide field of view on the drone's camera could compensate for the navigational error. But, the enemy's increasingly potent air defenses as well as the poor weather conditions in Vietnam drove the drone to operate mostly at lower altitudes, reducing its effectiveness. As noted above, the Lightning Bug managed to overfly its target on less than half its missions.[585] Later versions of the Ryan Model 147 cut the navigational drift rate to one percent, but even so, the Lightning Bug's sortie effectiveness never managed to approach those of manned reconnaissance aircraft.[586]

The Lightning Bug also suffered from complex launch and recovery systems. The immature technology of the day did not allow it to take off and land from a runway like manned aircraft. Instead, the Lightning Bug had to be loaded under the wing of a specially modified DC-130 aircraft. Mission accuracy depended on the DC-130 crew's ability to precisely launch the Ryan 147 at the pre-determined point because the drone could not figure out its location on its

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[583] "Navigational error accounted for almost half of the unsuccessful UAV sorties" [Ibid, 12].
[584] Ibid, 10.
[585] "Numerous single-point failures haunted drone operations. The first seven missions resulted in only two reels of film and a number of lost air vehicles, with most flights demonstrating poor navigational accuracy" [Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 38].
[586] One variant even featured a Doppler radar navigation system.

own. Any navigational error made by the DC-130 crew at the drone's mission-start point made the navigational error due to drifting gyros even worse. Aircraft recovery also proved a formidable technical challenge. The original recovery plan involved the deployment of a parachute above a pre-designated recovery point, but the delicate airframe could not withstand the damage suffered over the course of repeated recoveries.[587] Moreover, navigational error and unpredictable winds made it difficult to find the Lightning Bug when the system was left to drift down to the ground under a parachute. In order to reduce damage, a mid-air retrieval system using a recovery helicopter was developed. The helicopter plucked the drone out of mid-air with a hook before gently lowering it to the ground. Ironically, considering the Lightning Bug also required a host of electronic counter-measures aircraft (ECM) and fighter cover to protect the drone's ingress and egress from the target area, a veritable fleet of manned aircraft were required to support a single unmanned mission.[588] In addition to the DC-130, helicopter recovery bird, ECM aircraft, and fighter aircraft providing air cover, each Lightning Bug flight required a T-39 courier jet to deliver its film canister, assuming it was recovered intact, to Tan Son Nhut Air Base for film processing and analysis. It took days from mission tasking to the delivery of meaningful intelligence.[589] In total, more than thirty people were directly involved in one Lightning Bug mission.

[587] Drones were also damaged by high winds when their chutes failed to disengage on landing.
[588] "Air Force EB-66 Destroyers and Marine Corps EA-6 Prowlers provided 75 electronic warfare sorties per month in support of drone operations.207 Navy fighters protected the DC- 130 launch aircraft whenever it ventured close to the Gulf of Tonkin, and Air Force F-4 Phantoms provided combat air patrol for missions venturing into Laos" [Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 45].
[589] Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture," School of Advanced Air and Space Studies Monograph, June 2007, 24.

All these factors led to high costs. The Air Force calculated each Lightning Bug sortie cost $43,679.[590] In comparison, an RF-4C sortie cost, on average, $6,464.[591] The RF-4C, a manned reconnaissance jet whose job was to take pictures, performed essentially the same mission as the Lightning Bug, although its advanced sensor suite and in-flight re-tasking ability meant it offered much more capability than the Lightning Bug. Cost-per-target-figures reveal the same gross disparity: the cost per successfully covered target for the Lightning Bug was $5,500 versus $1,100 for the RF-4C.[592]

Not only were Lightning Bug operations much more expensive then the manned alternative, but Lightning Bugs also suffered from a vastly higher attrition rate. More than half, 533 to be exact, of the 1,016 Lightning Bugs flown in Vietnam were lost, one-third due to mechanical failure. That translated into an alarming 26% attrition rate per sortie. In comparison, RF-4Cs suffered significantly fewer losses; the Air Force lost 83 RF-4Cs during the course of the war, or less than a one percent attrition rate per sortie. Moreover, RF-4Cs flew 40-50 missions a day over Vietnam, which meant they completed the same number of reconnaissance missions every 10 weeks as the Lightning Bug flew over the entire 10 years of the war.[593]

Not surprisingly, when the Vietnam War ended in 1975, Air Force officials ended the program, choosing instead to fund competing manned aircraft projects and other technologies such as spy satellites. Although the Lightning Bug, at times, yielded valuable intelligence, the

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[590] Ibid, 11.
[591] Ibid.
[592] Ibid, 12.
[593] "The USAF's RF4C and 432nd Tactical Reconnaissance Wing (TRW)," http://www.talkingproud.us/Retired/Retired/Lavelle_files/page131-RF4Ccs-of-432nd-trw.pdf.

immature state of unmanned technology meant that the drone offered little relative value versus alternatives. Undersecretary of the Air Force James Plummer remarked:

> We are going to be cautious about initiating a vehicle development program where we don't have a good idea of the technological status and requirements of a support system. We simply cannot justify spending money to prove a concept which may have marginal utility.[594]

Likewise, Donald Fredericksen, Deputy Undersecretary of Defense for Research and Engineering stated, "The requirement for unmanned vehicles was there, but the technology was not yet adequate."[595] Funding for unmanned aircraft within the Air Force dropped from nearly $800 million at the end of the Vietnam War to zero by the early 1980s.[596]

Although the Lightning Bug did not survive to spawn a follow-on system, in a quirk of history, the program did have an important influence on General John Jumper, who, more than twenty years later, would play an instrumental role in the adoption of the Predator. Jumper's father, Major General John Jumper, served as the Seventh Air Force deputy chief of staff for intelligence.[597] In that position, he was well versed in the operations of the Lightning Bug. Impressed with the niche intelligence capability it provided, the senior Jumper remarked, "[The Lightning Bug] is the only reconnaissance system in theater that has the unique capability to fly

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[594] Negative attitudes about unmanned technology and its incompatibility with a warrior ethos undoubtedly colored budgeting decisions. Nevertheless, in the case of the Lightning Bug, its lack of value versus the manned alternative proved its undoing. Ehrhard remarks, "[Unmanned aircraft] proved acceptable (if expensive) for limited intensity conflict, but failed entirely to show meaningful utility for the major focus of Air Force plans in the 1970s" [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 463].

[595] Richard A. Best, "Intelligence Technology in the Post-Cold War Era: The Role of Unmanned Aerial Vehicles (UAVs)" (Washington, DC: Congressional Research Service, 26 July 1993), 8. Likewise, Ehrhard came to the following conclusion: "Technological immaturity, and more importantly, the relative shortfall in military effectiveness and efficiency compared to competitive systems, rendered the UAV a system in search of a mission" [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 488].

[596] Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture," School of Advanced Air and Space Studies Monograph, June 2007, 16.

[597] Seventh Air Force functioned as the Air Component Command of Military Assistance Command, Vietnam (MACV).

below prevailing cloud cover in safety during the northeast monsoon in North Vietnam, and is responsive to high priority requirements of this headquarters."[598] Jumper would instill an appreciation for unmanned aircraft in his son and namesake, indirectly helping to pave the way for future growth of the Predator.

The Army's Aquila

The U.S. Army has doggedly pursued unmanned aircraft technology ever since Colonel Sam Webster, an Army officer at Fort Huachuca Electronic Proving Grounds, installed a camera on a target drone in 1953.[599] Nevertheless, like the Air Force's experience with the Lightning Bug, technical difficulties and, to a certain extent, mismanagement prevented the Army from successfully bringing operational UAVs into its inventory until after the confluence of critical enabling technologies in the 1990s.

In 1979, the Army, unhappy with the Air Force's tactical reconnaissance support during the Vietnam War and aware the Air Force was phasing out its fleet of RF-4Cs, started a major acquisition effort to develop the Aquila. Originally, the Army planned to spend $123 million for a 43-month development period, followed by $440 million to procure 780 air vehicles and associated equipment. Eight years and over $1 billion later, the Army finally abandoned the program without accepting delivery of a single operational Aquila. As reported by the U.S. Government Accounting Office (GAO), "The original mission for Aquila was to have been

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598 The Seventh Air Force Commander, General John Vogt, the senior Jumper's boss, also gained an appreciation for unmanned aircraft. Vogt stated, "I know no other way we could have obtained the information we needed … [during] the intensive combat activity of the December period [Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture," School of Advanced Air and Space Studies Monograph, June 2007, 11].

599 Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 225.

relatively straightforward: it was to be a small, propeller-driven aircraft (portable by four soldiers) that could provide ground commanders with real-time battlefield information about enemy forces located beyond the line of sight of ground observers."[600] Various Army combat branches kept piling on requirements, however, until the Aquila became untenable. The GAO observed:

> Aquila was expected to fly by autopilot, carry sensors to locate and identify enemy point targets in day or night, use a laser to designate the targets for the Copperhead artillery projectile, provide conventional artillery adjustment, and survive against Soviet air defenses. Achieving the latter expectation required development of a jam-resistant, secure communications link, but using the secure link degraded the video quality, which interfered with the ability to do targeting. During operational testing in 1987, Aquila was only able to successfully meet mission requirements on 7 of 105 flights.[601]

Congress took notice of Aquila's expensive failure. Frustrated with a lack of tangible results after spending a significant amount of money, Congress froze R&D funding for UAVs for fiscal year 1988 and directed the Defense Department develop a coherent unmanned aircraft master plan. In 1989, Congress established the UAV Joint Project Office (JPO), which took away much of the services' latitude to pursue independent UAV programs, a significant step towards centralized management of UAV development. Four years later, Congress created the Defense Airborne Reconnaissance Office (DARO), an organization that took away the services' reconnaissance acquisition budget, assigning budget responsibility to senior leaders within the Department of Defense. "The DARO will be responsible for the development and acquisition of manned and unmanned platforms, their sensors, data links, data relays, and ground stations,"

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[600] General Accounting Office, "Statement of Louis J. Rodrigues, Director, Defense Acquisitions Issues, national Security and International Affairs Division," Testimony Before the Subcommittees on Military Research and Development and Military Procurement, Committee on National Security, House of Representatives (GAOT-NSIAD-97-138), 9 April 1997, available at http://www.dtic.mil/dtic/tr/fulltext/u2/a328322.pdf. The General Accounting Office was renamed the General Accountability Office (GAO) in 2004. The GAO is the audit, evaluation, and investigative arm of the United States Congress.
[601] Ibid.

declared Deputy Secretary of Defense William Perry in a memorandum outlining DARO's responsibilities.[602]

The creation of the UAV JPO and DARO, however, added to bureaucratic oversight, but yielded little improvement in the development and management of unmanned aircraft.[603] As a result, in an effort to streamline the development of new technology, the Department of Defense initiated the Advanced Concept Technology Demonstration (ACTD) Program in 1994 to bypass the normal acquisition process.[604] The Predator was one of the first programs selected as an ACTD.[605]

A Confluence of Critical Enabling Technologies

The Predator succeeded when previous UAV programs had failed because it benefited from the confluence of critical enabling technologies that occurred in the early 1990s. Technological advances, including GPS, advanced micro-processors, and wide-band satellite communication links, allowed Predator to overcome technological challenges that plagued previous UAVs. Without the benefits of these technological advances, it is highly likely that unmanned aircraft would have continued to founder in an emergent state.

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602 Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture," School of Advanced Air and Space Studies Monograph, June 2007, 17.
603 Houston Cantwell, "RADM Thomas J. Cassidy's MQ-1 Predator: The USAF's First UAV Success Story," Air Command and Staff College Monograph, April 2006, 6.
604 The Department of Defense did not initiate the ACTD program solely because of UAV management problems. All of its weapons and information systems development programs, including UAVs, suffered from "taking too long, costing too much, and not adequately involving those who ultimately use the equipment" [Congressional Budget Office, "The Department of Defense's Advanced Concept Technology Demonstrations," September 1998, http://www.cbo.gov/doc.cfm?index=865&type=0]. As a result, the DoD initiated the ACTD program in hopes of addressing those problems.
605 DARO, which was still responsible for developing and managing the airborne reconnaissance architecture, provided the initial funding for the Predator ACTD, and the UAV JPO provided day-to-day management of the ACTD.

Predator was born on January 7, 1994 when General Atomics (GA) was awarded a $31.7 million ACTD contract to deliver 10 prototype drones. It was nearly stillborn since the U.S. Air Force was run by General Merrill McPeak, a fighter pilot who was decidedly unfriendly to unmanned aircraft.[606] McPeak wanted nothing to do with the Predator ACTD and rejected any involvement in the program. As a result, the Predator program manager had to shop the project around among the other services. He found a sponsor in Lieutenant General Paul Menoher, the head of Army intelligence. Menoher jumped at the opportunity to take a large role in the ACTD and dedicated a whole company of experienced pilots from a Military Intelligence Battalion to the effort.[607]

The Predator program immediately chalked up a string of early successes. GA promised the drone would fly its first test flight no later than six months after the contract was awarded, and in July 1984, the company delivered on that promise.[608] In May and June 1995, only 18 months after being selected for the ACTD contract, Predator was sent to ROVING SANDS, a joint exercise in the southwestern United States, where it provided reconnaissance on over 200 assignments, many of which were difficult-to-find mobile targets. Its success at ROVING SANDS convinced senior leaders to deploy the Predator, still in a prototype stage, to support combat operations in the Balkans. Remarkably, less than a year after its first flight, the Predator

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[606] McPeak served as Air Force chief of staff from 1990-1994. "The Air Force, for its part, remained disinterested in UAVs during McPeak's tenure as Chief of Staff" [Thomas Ehrhard, *Air Force UAVs: The Secret History* (Arlington, VA: Mitchell Institute Press, 2010), 47].

[607] The majority of the Predator's initial pilots were Army warrant officers with helicopter experience. The Navy also coughed up several Navy Reserve pilots with intelligence backgrounds to fly the Predator during its testing phase [Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), footnote 439, 81]. Menoher dedicated C Company of the U.S. Army's 204th Military Intelligence Battalion (Aerial Reconnaissance) to the Predator program. Prior to flying the Predator, C Company pilots flew the GUARDRAIL – V, a modified RC-12 surveillance aircraft. C Company retired the GUARDRAIL-V system in 1994, just prior to the Predator's ACTD.

[608] Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture," School of Advanced Air and Space Studies Monograph, June 2007, 18.

demonstrated its utility flying combat missions over the former Yugoslavia.[609] The first tour was so successful that ground commanders insisted that the Predator extend its deployment well past the date it was supposed to redeploy back to the United States. Predator's timing was particularly fortuitous since the senior policy makers were not willing to risk casualties but wanted better reconnaissance information than satellites could manage.[610] The drone was also helped by the fact that the U.S. Air Force had retired most of its tactical reconnaissance assets, which left a void for the Predator to fill. Over the next four years, the Predator would go on to prove its worth in combat, completing multiple deployments in support of Balkan operations.[611] Unlike the $1 billion wasted on the Aquila, the $31.7 million ACTD contract for delivery of 10 Predator prototypes seemed like a bargain, leading many defense department officials to refer to the Predator as the "ACTD Poster Child."[612]

The Predator was able to deliver a string of early successes, in part, because it benefited from millions of dollars sunk into two experimental programs—"Amber" and the Gnat-750.[613] In fact, Thomas Cassidy, a retired admiral who served as chief executive officer of General Atomics Aeronautical Systems, Inc., attributes the Predator's early successes to his company's

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[609] The Predator was launched from an airfield in Gjader, Albania during its first combat deployment to the Balkans. The Predator flew 52 missions on its first deployment, with one being shot down by Serbian anti-aircraft artillery and the other lost due to mechanical difficulty. Although the operating environment was relatively benign (although poor European weather , however, was an issue), the Predator racked up an attrition rate of less than 4% per sortie, a big improvement form the Lightning Bug's 26% sortie attrition rate.

[610] Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 52.

[611] The Predator's first combat deployment in 1995 in support of Operation Nomad Vigil was promptly followed by another combat tour in support of Operation Joint Endeavor in 1996 and then again in 1998 in support of Operation Joint Guard. The Predator would later make periodic re-deployments back to the Balkans through 2001, most notably in support of OPERATION ALLIED FORCE in 1999. "The objective of the ACTD period was simply to demonstrate military utility. Predator had accomplished that objective through several joint exercises and contingency operations" [Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture," School of Advanced Air and Space Studies Monograph, June 2007, 19].

[612] "Tally Up- After Nearly Four Years and $1.8 Billion, The Pentagon's vaunted ACTD Process is an Enduring Operation- Results Still to Come," *Armed Forces Journal*, July 1998, 22.

[613] The Predator's "Amber" and Gnat-750 roots "allowed for enough maturity that it worked as a demonstration even though it had little or no support structure" [Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 52].

decision to base the platform on "technologies that work."[614] The Predator was derived from a highly-classified Central Intelligence Agency (CIA) drone code-named "Amber," originally developed by Abraham Karem, a former chief designer for the Israeli Air Force.[615] Built in the mid-1980s, Amber showed considerable technological promise but was too small to carry sufficient fuel and sensors.[616] Furthermore, it lacked the necessary stability to provide high-quality video imagery. In 1988, Karem's company began developing a larger version of the drone. The new UAV first flew in the summer of 1989, but by that time, Karem's company was experiencing serious financial difficulties. GA purchased Karem's company in 1990 and decided to continue development of the new, larger UAV which they named the Gnat-750.[617]

In 1993, GA sold two Gnat-750s to the Defense Department, which transferred control of the aircraft to the Central Intelligence Agency (CIA). The CIA experimented with the drones, crashing one of them.[618] In February 1994, the CIA sent its surviving Gnat-750 and another leased bird on a trial deployment to Albania to conduct surveillance operations over the former Yugoslavia. The trial deployment gave GA an opportunity to identify major technological shortcomings, which it later fixed when it delivered the ten Predator prototypes to fulfill its ACTD contract.

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[614] Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture," School of Advanced Air and Space Studies Monograph, June 2007, 20.

[615] The Navy also had a hand in Amber's development. The Navy's acquisition of the Tomahawk, a very long-range surface-to-surface cruise missile, gave it the ability to target Soviet navy ships at considerable distances, but the Navy lacked a way to figure out the position of Soviet ships under way. The Navy became interested in Amber as a way to find, fix, and track Soviet ships and thus, avoid having to steam inside the lethal range of Soviet systems to get a good shot [Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 21].

[616] Approximately 13 "Amber" drones were built [Bill Yenne, *Birds of Prey: Predators, Reapers and America's Newest UAVs in Combat* (North Branch, MN: Specialty Press, 2010), 37].

[617] "General Atomics Predator," http://www.spyflight.co.uk/predator.htm.

[618] The drone crashed after a gust of wind caused its pitot-static system to momentarily sense zero airspeed. The plane thought it was on the ground, which caused it to invoke flight control logic incompatible with flight, and it plummeted to the ground ["Unmanned Aircraft: US Battlefield UAVs," http://www.vectorsite.net/twuav_07.html].

The biggest operational limitation that surfaced during the Gant-750's deployment stemmed from the way the drone was controlled.[619] The Gnat-750 was designed to be controlled via line-of-sight, C-band radio waves, which meant that the air vehicle was tethered to a nearby ground-control station.[620] The curvature of the earth naturally limits the maximum range of line-of-sight control to approximately seventy miles, and that, of course, assumes flat terrain. Man-made and natural obstacles such as buildings and mountains further reduce the maximum range of this type of remote control. Hence, the drone suffered from a severely limited range. To extend the Gnat-750's range, the CIA experimented with using a Schweitzer RG-8 motor glider as an airborne relay, but that work-around solution delivered limited success.[621] Flying from Albania, the slow motor glider took an inordinate amount of time to reach its relay orbit, and then only had enough gas to spend two hours on station. This complicated operations and also negated the benefit of the Gnat-750's thirty-hour endurance. Additionally, bad weather and data-link-relay problems while operating over the mountainous terrain of the former Yugoslavia compounded the Gnat-750's operational difficulties, leading the CIA to cut short its deployment.[622]

Applying lessons learned from the Gnat-750's experience, GA modified the shape of Predator's airframe, designing it with a bulbous nose in order to accommodate a dish to enable

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[619] It also became apparent that the Gnat-750's engine, a Rotax 912 which produced 85 horsepower, was considerably underpowered. This deficiency in power limited the payload the aircraft could carry. GA switched out engines when it built the Predator, substituting the more powerful Rotax 914, a turbo-charged engine that produces 105 horsepower [U.S. Air Force Fact Sheet, "MQ-1 Predator," available at http://www.af.mil/information/factsheets/factsheet.asp?id=122].

[620] Line-of-sight control requires a clear path between the aircraft and the broadcast antenna on the ground-control station.

[621] The Aquila program also experimented with a multi-UAV line-of-sight relay system. The results were less than satisfactory.

[622] "General Atomics Predator," http://www.spyflight.co.uk/predator.htm. The two GNAT-750s were refitted with a thermal imaging sensor and an improved signals intelligence package and redeployed to Croatia. On its second test deployment, the Gnat-750 achieved significantly more effective performance, but serious operational limitations remained.

real-time control via satellite signals. Such control would not have been possible without recent technological advances made in the commercial satellite and computer industries. Specifically, wideband satellite connectivity, developed to support commercial communications, and high-speed microprocessors were instrumental in making real-time satellite control possible.[623] The use of satellite control untethered the air vehicle from the ground-control station, solving one of the Gnat-750's range issues.[624]

Satellite control allows a concept called "remote split operations" (RSO). Because there is a slight delay (less than a second) using satellite control, Predator has to take off using line-of-sight radio control. Predator was one of the first operational UAVs to take off and land from conventional runways used by manned aircraft, thereby negating the need for complex launch and recovery methods that invariably increased costs and decreased mission effectiveness. Operators in a nearby ground-control station receive imagery from a camera mounted in the Predator's nose, thus giving pilots a view similar to the one they would have looking out the front windscreen of a cockpit.[625] Once airborne, the pilot transfers control to another crew controlling the air vehicle via satellite signals. The crew controlling the plane via satellite signals can literally be located anywhere on earth thanks to advancements made in communications technology. In fact, the vast majority of Predator missions flown over Iraq and Afghanistan were controlled from locations in the United States, more than 7,000 miles away. A

[623] Commercial innovation often powers military innovation (see Chapter 2).

[624] Note: the U.S. Army does not consider satellite connectivity essential for unmanned aircraft operations because its preferred doctrine is to link airpower to specific units and hence, using line-of-sight control and being tethered to a ground station is less of an issue. Consequently, the U.S. Army initially chose not to operate its unmanned aircraft using satellite control.

[625] Landing a Predator is significantly more difficult than a manned aircraft, however. The two-dimensional video screen does not provide the same depth perception, proprioperceptive (seat-of-the-pants), and peripheral cues airborne pilots use to discern when to flare an aircraft for landing. Moreover, significant crosswinds may mean the camera's view is angled significantly away from the runway [source: personal experience as a Predator pilot and squadron commander].

revolutionary concept that is starting fundamentally to rewrite the rules of battle, RSO enables power projection with minimal footprint and vulnerability.

Not only was Predator the first operational UAV to cast off line-of-sight range limitations through the use of satellite technology, but it was also was the first operational UAV to use GPS satellite signals for navigation.[626] GPS eliminated a major driver of mission failure among earlier unmanned systems—inaccurate navigation.[627] A light-weight, low-cost receiver is now all that is required for pinpoint, reliable navigation. The critical capability that GPS provides cannot be understated; almost every major UAV system today relies on GPS for basic aircraft operations.

The Department of Defense did not develop its expensive constellation of GPS satellites specifically for unmanned aircraft. GPS satellites were put into orbit to give our nation's nuclear forces precise location information.[628] In other words, GPS was developed as a sustaining innovation to support existing weapons.[629] The Predator's timing in terms of benefiting from GPS was unplanned but fortuitous. The GPS reached "initial operating

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[626] Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 49.
[627] As detailed earlier, navigational error was the main driver of mission failure for the Lightning Bug.
[628] "While there were wide needs for accurate navigation in military and civilian sectors, almost none of those were seen as justification for the billions of dollars it would cost in research, development, deployment, and operation for a constellation of navigation satellites. During the Cold War arms race, the nuclear threat to the existence of the United States was the one need that did justify this cost in the view of the US Congress. This deterrent effect is why GPS was funded. The nuclear triad consisted of the US Navy's submarine-launched ballistic missiles (SLBMs) along with the US Air Force's strategic bombers and intercontinental ballistic missiles (ICBMs). Considered vital to the nuclear deterrence posture, accurate determination of the SLBM launch position was a force multiplier" ["History of GPS," available at http://www.gpstracker77.info/history-of-GPS.php]. During the 1960s and 1970s, there was also a move afoot to make U.S. land-based nuclear missiles more survivable by making them mobile, exactly as the Soviets had done. Mobile intercontinental ballistic missiles (ICBMs) needed to precisely fix their launch position in order to accurately delivery their nuclear ordnance. Additionally, manned strategic bombers benefited from GPS.
[629] It is fairly typical for disruptive innovation to be an inadvertent beneficiary of sustaining innovation (see Chapter 2).

capability" in December 1993, just in time for the Predator's ACTD.[630] GPS signals were available before 1994, but on a limited basis.[631]

The Predator also reaped benefits immeasurably from the digital revolution. The miniaturization of computers and exponential improvements in computing power allowed UAVs to carry more capable payloads and pass that information through more jam-resistant, higher-bandwidth data links.[632] Additionally, because sensor information and electronic intelligence are beamed directly via satellite to the Predator's ground-control station, it is relatively easy to capture and send real-time video feeds anywhere around the planet over the military's secure internet. This capability provides unparalleled portability and distribution of intelligence. Real-time full-motion video is available to anyone with a computer terminal that has access to the military's information grid. In sharp contrast, as mentioned earlier, meaningful intelligence was available only several days after a Lightning Bug mission.

Agents of Change

Three agents of change—General Ronald Fogleman, General John Jumper, and Secretary of Defense Robert Gates—were instrumental in pushing unmanned aircraft beyond an emergent phase and into the technology's takeoff and growth stage of its life cycle.[633]

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[630] National Academy of Sciences, "The Global Positioning System: The Role of Atomic Clocks," April 1997, available at http://www.beyonddiscovery.org/includes/DBFile.asp?ID=84.
[631] GPS signals were available before 1994 but on a limited basis. The Air Force launched its twenty-fourth Navstar satellite into orbit, completing the global network of navigational satellites in June 1994. Before the mid-1990s, the U.S. military had yet to integrate GPS receivers into its aviation fleet, although it had conducted limited experiments and produced prototypes. During the Persian Gulf War in 1991, innovative aircrew taped GPS receivers that were not certified for aviation use to the instrument panels of their fixed-wing aircraft and helicopters ["GPS History, Chronology, and Budgets" in *The Global Positioning System*, Rand report MR614, 245, available at http://www.cs.cmu.edu/~sensing-sensors/readings/GPS_History-MR614.appb.pdf].
[632] Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 47.
[633] General Norman Schwartz, the current U.S. Air Force chief of staff, has also been UAV friendly.

Fogleman, the Air Force chief from 1994 to 1997, sensed the technology had become viable and stole the program away from the Army. After Fogleman retired, Jumper, who served as the commander of United States Air Forces in Europe from 1997 to 2000, the commander of Air Combat Command from 2000 to 2001, and later as chief of staff of the Air Force from 2001 to 2005, carried the UAV torch, weaponizing the Predator and shepherding the unmanned aircraft through the beginnings of its growth phase. Finally, Gates, the Secretary of Defense from 2006 to 2011, helped accelerate UAV growth and started to enforce tradeoffs, cannibalizing manned aircraft to fund an expanded unmanned fleet.

Fogleman Senses a "Transition Point"

Ronald Fogleman succeeded the decidedly UAV-unfriendly Tony McPeak in October 1994, nine months after the birth of the Predator program. Whereas the Air Force originally rejected any sort of involvement early in the Predator program, Fogleman sensed unmanned aircraft technology was at a point of inflection and decided to act.[634] In a major policy shift, Fogleman made an all-out bid to steal the Predator away from the Army, lobbying the Secretary of Defense to make the Air Force the "lead service" for the aircraft. Fogleman did not necessarily act because there had been a change in the strategic situation, as Barry Posen and Stephen Rosen's theories suggest, but rather because he sensed that airpower was, in his words, at a technological "transition point" and he saw himself as an agent of change.[635] In

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[634] The Air Force even rejected operational control of Predator operations when it was first deployed to Bosnia. The Air Force's only involvement early in the Predator program was, as noted earlier, to send a single B-52 pilot to help fly the air vehicle.

[635] Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 51. From the beginning of his tenure as chief, Fogleman recognized that the Air Force "could no longer … spend money the way we have been" and ordered his planners to think "outside the box." Part of that mandate was to explore

announcing the Air Force's change of heart when it came to unmanned aircraft, Fogleman stated, "We are now impressed by the convergence of technological advances in computers, flight controls, lightweight materials, advanced electric motors and communications packages that will make modern UAVs extremely effective."[636] He continued, "The Air Force has come to realize the enormous potential of UAVs and is eager to capitalize on it."[637]

General Fogleman next used his bully pulpit as chief to get other senior Air Force officers in line with his vision, a technique reminiscent of General Thomas White's advocacy of ICBMs within the Air Force (see Chapter 3). In August 1995, Fogleman released a policy letter in which he declared the Air Force would pursue the vigorous adoption of unmanned aircraft. In the letter, Fogleman acknowledged that the Air Force, in the past, had legitimate reservation about UAVs for a variety of reasons.[638] But, he cited technological improvements as reason for change. Fogleman stated, "UAVs hold great promise to perform many theater reconnaissance operations--from surveillance to targeting and bomb damage assessment. Beyond these, we are contemplating their use in a variety of other operations, from peacekeeping or peace enforcement to counterdrug, counterterrorism, peacetime surveillance and even strike operations."[639] Highlighting a theme that Jumper would later embrace with fervor, Fogleman predicted UAVs would help reduce the time it takes to find and destroy targets.

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emerging technologies "such as UAVs" [John A. Tirpak, "Robotic Air Force," *Air Force Magazine*, September 1997, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1997/September%201997/0997robotic.aspx].

[636] Sue Baker, "AF Creates UAV Office," *Air Force News Service*, unspecified date in 1995, available at www.fas.org/irp/news/1995/n19951114_1260.html. Note: advancements in satellite connectivity occurred in the early 2000s, after Fogleman's tenure as Air Force chief.

[637] Ibid.

[638] Ibid.

[639] Ibid.

In the fall of 1996, Fogleman took advantage of CORONA, a forum where the entire Air Force senior leadership gathers for "frank, open discussions and decision-making about the future," to advocate for an increasingly UAV-centric Air Force.[640] Even though Fogleman was convinced that embracing the Predator was the right thing to do for the service, other senior Air Force generals remained recalcitrant to the idea of adopting unmanned aircraft, preferring instead that the Air Force stay wedded to existing manned systems.[641] Fogleman laid his cards on the table at CORONA, declaring, "The bottom line is that on my watch, the Air Force will embrace UAVs and work to fully exploit their potential. We are committed to making UAVs successful contributors to our nation's joint war fighting capability."[642] Fogleman's CORONA declaration was very similar to Thomas White's to bomber generals in May 1954: "Ballistic missiles are here to stay—you need to realize that and get on with it."[643]

Although Fogleman's badgering did not convince everyone, it did eliminate much of the vocal opposition as other senior leaders did not want openly to cross the chief. Fogleman secured a broad, if not bland, commitment among senior leaders that the Air Force would

[640] Julie Weckerlein, "Top General Meet at Corona," *Air Force News*, 9 February 2006, available at http://www.af.mil/news/story.asp?id=123016180.

[641] General Kenneth Israel, the assistant deputy undersecretary of defense for airborne reconnaissance, and director of the DARO, told the *Wall Street Journal* that "the pilot-dominated Air Force hierarchy has always been biased against unmanned aerial vehicles," but also added that there also were "pockets of support" [Thomas E. Ricks and Anne Marie Squeo, "The Price Of Power -- Sticking To Its Guns: Why the Pentagon Is Often Slow to Pursue Promising Weapons: Resistance and Neglect Kept Drones From Soaring, Despite Their Advantages," *Wall Street Journal*, 12 October 1999, A1, available at http://www.pulitzer.org/archives/6361].

[642] Michael W. Kennedy, "A Moderate Course For USAF UAV Development," Air Command and Staff College Monograph, April 1998, 16. Fogleman tried to use the Army and Marine Corps' expressed anxiousness to capitalize on UAVs to "convince the rest of the four-stars that we (USAF) need to get on board" with UAVs. "Sister service expansion was a 'major concern' at CORONA Fall 96. … it seems the Air Force saw the "UAV train" leaving the station and decided it had better get on or be left behind" [Michael W. Kennedy, "A Moderate Course For USAF UAV Development," Air Command and Staff College Monograph, April 1998, 18].

[643] T. A. Heppenheimer, *Facing the Heat Barrier: A History of Hypersonics* (Washington, DC: National Aeronautics and Space Administration, 2007), 28.

“increase its ‘strategic investment stream’ in this area.”[644] The Air Force’s Long-Range Plan wryly noted, “At CORONA Fall 1996, the Air Force's most senior leaders stepped up to the issues of mounting global challenges and rapid technological change to develop a vision for the future.”[645]

In November 1996, Fogleman issued his capstone *Global Engagement: A Vision for the 21st Century Air Force*, a document that charted a new strategic course for the airpower institution. The document included an “aggressive path for implementation of UAVs over the full range of combat missions.”[646] *Global Engagement* declared:

> The Air Force will exploit the technological promise of Unmanned Aerial Vehicles (UAVs) and explore their potential uses over the full range of combat missions. The highest payoff applications in the near-term are Intelligence, Surveillance, Reconnaissance (ISR) and communications. A dedicated Air Force UAV squadron will focus on operating the Predator medium-range surveillance UAV, which also will serve as a testbed for developing concepts for operating high altitude, long endurance UAVs. In the mid-term, the Air Force expects that suppression-of-enemy-air defense (SEAD) missions may be conducted from UAVs, while the migration of additional missions to UAVs will depend upon technology maturation, affordability and the evolution to other forms of warfare.[647]

After wrestling away control of the Predator program from the Army, Fogleman moved operations from Fort Huachuca, Arizona first to Nellis Air Force Base and later Indian Springs Air Force Base, Nevada.[648] Fogleman then directed the reactivation of the 11th Reconnaissance

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644 Michael W. Kennedy, “A Moderate Course For USAF UAV Development,” Air Command and Staff College Monograph, April 1998, 16.
645 U.S. Air Force, “The 1997 Air Force Long-Range Plan: Summary,” available at http://www.au.af.mil/au/awc/awcgate/af-lrp97.htm.
646 Michael W. Kennedy, “A Moderate Course For USAF UAV Development,” Air Command and Staff College Monograph, April 1998, 20.
647 Ronald R. Fogleman and Sheila E. Widnall, “Global Engagement: A Vision for the 21st Century Air Force,” 1997, available at http://www.au.af.mil/au/awc/awcgate/global/global.pdf.
648 Indian Springs was later renamed Creech Air Force Base. Whereas Fort Huachuca had issues gaining training airspace from the Federal Aviation Administration, launching Predator sorties from Creech Air Force Base gave Air Force crews access to much better training airspace in the Nevada Test and Training Range, a massive 4,687 square miles of protected airspace, the largest of its kind in the United States.

Squadron and gave the unit leadership the task of normalizing the UAV business.[649] He sent experienced pilots, against their wishes, to fly the Predator to ensure the program's success. "If this program fails, it won't be because of our pilots," stated Fogleman.[650]

In addition to adopting the Predator, Fogleman advocated replacing the U-2 with the RQ-4 Global Hawk, an unmanned aircraft, and reprogrammed substantial USAF research and development money to fund the development of a strike UAV.[651]

Although Fogleman laid the groundwork for change, he became so frustrated with organizational politics that favored the status quo that he quit.[652] "I began to question some of the things that we were doing, or that we were planning to do, based on old paradigms—but

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[649] Bill Yenne, *Birds of Prey: Predators, Reapers and America's Newest UAVs in Combat* (North Branch, MN: Specialty Press, 2010), 29. The 11th Reconnaissance Squadron had operated Firebee drones from 1971 until it was deactivated in 1979. The Lightning Bug was a derivative of the Firebee.

[650] Fogleman also allowed experienced navigators to fly the Predator so long as they also possessed a Federal Aviation Administration commercial/instrument pilot license. He did this to increase the pool of aviators from which operators were selected. Under Jumper's leadership, the Air Force would later change the rules to allow pilots flying unmanned aircraft to accumulate "gate months," time in the cockpit that allowed them to satisfy pilot incentive-pay requirements, just as if they were flying a conventional aircraft.
[James G. Roche, Secretary of the Air Force, memorandum for ALMAJCOM-DRU/CC. subject: Air Force Policy Regarding OFDA Credit for UAV Crews, 25 April, 2002].

[651] Thomas Ehrhard, *Air Force UAVs: The Secret History* (Arlington, VA: Mitchell Institute Press, 2010), 56. The U-2, a manned high-altitude reconnaissance aircraft that flies upwards of 70,000+ feet, was designed in the 1950s to monitor Soviet nuclear sites. Since then, the U-2 has evolved to carry an increasingly capable array of sensors. The Global Hawk, an unmanned spy plane with a wingspan of approximately 130 feet that flies at 60,000 feet, while still a developmental system, deployed operationally to support the Global War on Terror in November 2001. The Global Hawk program has struggled to contain costs and deliver value. As reported by *New York Times*, "The Global Hawk has become the Escalade of drones, the gold-plated one that nearly broke the bank" [Christopher Drew, "Costly Drone Is Poised to Replace U-2 Spy Plane," *New York Times*, 2 August 2011, available at http://www.nytimes.com/2011/08/03/business/global-hawk-is-poised-to-replace-u-2-spy-plane.html?pagewanted=all]. Thus, the Global Hawk's story is similar to the Aquila's, but has yet to suffer the same fate (see earlier in the chapter).

[652] "The Early Retirement of General Ronald R. Fogleman, Chief of Staff, United States Air Force," *Aerospace Power Journal,* Ed. Richard Kohn, Spring 2001, available at http://www.airpower.au.af.mil/airchronicles/apj/apj01/spr01/kohn.htm. Fogleman also had other disagreements with the civilian leadership. He believed Brigadier General Terryl "Terry" Schwalier, the on-site wing commander during the Khobar Towers terrorist attack, should have been promoted to major general because he took all foreseeable precautions to protect the base and thought the civilian leadership was abandoning him for political expedience (i.e., without cause) because they needed a scapegoat [see "The Vindication of General Schwalier," 14 January 2008, http://formerspook.blogspot.com/2008/01/vindication-of-general-schwalier.html]. Additionally, Fogleman threatened to quit when Secretary Widnall contemplated giving Kelly Flinn, the first female B-52 pilot who repeatedly violated the military's fraternization rules, an honorable discharge. Flinn was allowed to leave the military with a general discharge rather than face a court martial.

not very successfully," Fogleman said.[653] The general became the only voice of dissent inside "the tank," a conference room where the service chiefs meet. In fact, he called some of the decisions the group made "absurd."[654] Fogleman, to use his own words, "sincerely believed that the nation was at a unique crossroads … and that we had an opportunity—if we could have a serious discussion about national security strategy and defense issues—to restructure our military into a smaller, better focused institution to respond to the kinds of challenges coming in the next 10 to 15 years."[655] His inputs, however, seemed to fall on deaf ears as the other chiefs were not interested in leading change. Fogleman thought the other chiefs were interested only in "horse-trading … being bought off" rather than being interested in genuine change.[656] Fogleman commented that "service parochialism, the willingness to collectively go along with something because there was at least some payoff for your service somewhere in there," was endemic among his colleagues.[657]

In September 1996, after a session discussing the upcoming Quadrennial Defense Review, Fogleman got a visit from a two-star general with a message from General John Shalikashvili, then chairman of the Joint Chiefs of Staff. Fogleman describes what happened next:

> He sat on that couch in the chief's office and said, "I have a message from the chairman, and the message is, that in the QDR we want to work hard to try and maintain as close to the status quo as we can. In fact, the chairman says we don't need any Billy Mitchells during this process." That shocked me a little bit. I replied, "Well, that's an unfortunate

[653] "The Early Retirement of General Ronald R. Fogleman, Chief of Staff, United States Air Force," *Aerospace Power Journal,* Ed. Richard Kohn, Spring 2001, available at http://www.airpower.au.af.mil/airchronicles/apj/apj01/spr01/kohn.htm.
[654] Ibid.
[655] Ibid.
[656] Ibid.
[657] Ibid.

> use of a term, but I understand the message." From that point on, I really did not have much hope for the QDR. … I lost all hope …[658]

After being stymied in his efforts to institute change by his uniformed peers and after interacting with a civilian leadership that "took any kind of military advice that ran counter to administration policy or desires as a sign of disloyalty on the part of the person providing the advice," Fogleman realized he had become an ineffective spokesman for innovation and retired in 1997, one year before the end of his second term as chief.[659]

Jumper Carries the UAV Torch

General Michael E. Ryan replaced Fogleman as chief, but Ryan, in the words of General Kenneth Israel, the director of DARO, provided "at best a lukewarm endorsement" of unmanned aircraft.[660] Nevertheless, Jumper carried the torch for UAVs within the Air Force, helping to push the technology forward. Before replacing Ryan as chief, Jumper nurtured the technology from an emergence to initial growth. Later as chief, he ushered in a relatively rapid uptick in the number of Predators in the Air Force's inventory.

While serving as the commander of United States Air Forces in Europe, Jumper saw first-hand the intelligence capabilities that the Predator provided. The drone delivered real-time video to the Air Operations Center (AOC), the command and control center that oversaw air operations over the former Yugoslavia. Although impressed with the Predator's early success providing persistent reconnaissance, Jumper repeatedly witnessed what he called the "dialogue

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658 Ibid.
659 Ibid.
660 Thomas E. Ricks and Anne Marie Squeo, "The Price Of Power -- Sticking To Its Guns: Why the Pentagon Is Often Slow to Pursue Promising Weapons: Resistance and Neglect Kept Drones From Soaring, Despite Their Advantages," *Wall Street Journal*, 12 October 1999, A1, available at http://www.pulitzer.org/archives/6361.

of the deaf," described in the following excerpt from a School of Advanced Air and Space Studies monograph:[661]

> The dialogue began when a Predator pilot located a target of opportunity, often times a tank. The Predator pilot would radio a strike asset, like an A-10 Warthog, and begin a frustrating exchange of radio communication in an effort to talk the eyes of the A-10 pilot onto the tank. The Predator pilot would tell the A-10 pilot, "The tank is between the two red-roofed buildings—and if you look to the left, there's a road that runs next to them." The A-10 pilot, circling an entire city at 15,000', saw numerous red roofed buildings and countless roads. He needed better information. By the time the A-10 returned to base for fuel, the two might, "be in the same zip code," but certainly were not looking at the same target. "You'd have the Predator up there looking at targets, but you had no way to get that information, other than verbally, to the airplanes that were going to attack those tanks," said Jumper.[662]

Jumper called Ryan and informed him of an urgent requirement for the Predator to provide precise geographic locations of subjects it was observing.[663] Ryan agreed to the request and directed Big Safari, a specialized office that cuts through the normal acquisition bureaucracy to quickly develop special-purpose aircraft, to find a way to make the Predator more combat-effective. Within 18 hours, Big Safari located a suitable system, a multi-spectral targeting system (MTS) manufactured by Raytheon, to hang underneath the Predator's "chin." Not only did the system improve the fidelity of the Predator's sensor camera, but it also included an infrared camera and a laser designator and rangefinder system. This gave the Predator the ability to quickly pass precise coordinates of the targets it was observing to other aircraft or even "laze" (fire a laser beam at) a target, directing a laser-guided munition dropped

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[661] Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture, School of Advanced Air and Space Studies Monograph, June 2007, 25.

[662] Ibid. "Jumper had just been called by Lt. Gen. Michael C. Short, the commander of USAFE's 16th Air Force. Short had learned from a conversation with his son, an A-10 pilot, that although Predator operators could see targets the UAV was reconnoitering, there was no effective way to direct strike aircraft to the targets. What typically resulted was a cumbersome and inefficient conversation as the Predator operators attempted to 'talk' fighter pilots to the targets" [Walter Boyne, "How the Predator Grew Teeth," Air Force Magazine, July 2009, 43].

[663] Ibid.

from another platform. Jumper called the installation of the MTS a breakthrough.[664] As he put it, the laser ball "turns the Predator from just a pure surveillance system into something that actually … directs weapons on the targets."[665]

In February 2000, Jumper took command of Air Combat Command, where he continued to identify ways to shorten what he called the "kill chain," the time between identifying a target and destroying it.[666] To his dismay, he discovered that maintenance personnel had removed the MTS balls when the Predators had been shipped back stateside after the end of operations over the former Yugoslavia because the equipment was not part of the program of record. Jumper immediately ordered them re-installed.

Not satisfied with the status quo, Jumper took the next logical step in the Predator's technological advancement and ordered the airframe be armed.[667] He thought an armed Predator would effectively take care of fleeting and perishable targets, ones that could get away quickly.[668] "It seemed obvious to me that if you have a vehicle out there that is staring at a target, it probably ought to have something on board that can do something about it,"

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664 Bill Yenne, *Birds of Prey: Predators, Reapers and America's Newest UAVs in Combat* (North Branch, MN: Specialty Press, 2010), 43
665 Ibid.
666 Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture, School of Advanced Air and Space Studies Monograph, June 2007, 26.
667 Thomas Ehrhard wrote: "Perhaps the most daunting obstacles that confronted the [Predator] were the numerous arms control treaties that restricted cruise missiles and, by specific language and negotiating record precedent, UAVs that deliver weapons. The most difficult language … came from the INF treaty, which banned ground-launched, unmanned air vehicles with ranges more than 310 miles" [Thomas Ehrhard, *Air Force UAVs: The Secret History* (Arlington, VA: Mitchell Institute Press, 2010), 56]. This legal barrier to entry, however, was overcome fairly swiftly. After a close examination of the text of each treaty, a compliance review board consisting of Defense and State officials concluded that the text of the INF treaty was ambiguous enough to allow the Predator to be armed. Testing of armed Predators commenced in early 2001, without interruption.
668 Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture, School of Advanced Air and Space Studies Monograph, June 2007, 26. Jumper subsequently learned of an incident where a CIA Predator reportedly found Osama bin Laden, but he escaped because the Predator had no way to attack him. Navy Tomahawk cruise missiles called into action arrived too late.

Jumper recalled.[669] Never designed to be armed, the Predator's maximum payload capacity was less than 500 pounds. Hence, it was unable to carry the lightest "dumb" bomb then in the Air Force's inventory. Consequently, Jumper opted for one of the few alternatives, a 105-lb laser-guided missile originally designed to be shot off attack helicopters, the AGM-114 Hellfire.[670] Jumper's request to arm the Predator met with resistance from regular acquisition channels, so he turned back to Big Safari for help, telling them that he would accept any and all risk of program failure. "Take three months and $3 million, and you go do it, just do it," directed Jumper.[671] Big Safari came through again, just like they had with the MTS. The first Hellfire shot from a Predator occurred on 7 October 2001, a mere 86 days after Jumper had set Big Safari loose on the task. The first combat shot took place five months later.[672]

When America went to war in Afghanistan and Iraq in 2001 and 2003 respectively, its operational UAV fleet was still relatively small, but thanks to Jumper's push to advance the technology, the Predator was poised for a breakout. "We're going to tell General Atomics to build every Predator they can possibly build," declared Jumper when he became chief of staff.[673] Under his leadership, the number of daily unmanned combat air patrols (CAPs) the Air Force flew ballooned from one at the start of the conflict in 2001 to a dozen by the end of his tenure. The Predator rapidly went from an experimental footnote to the top-requested air

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[669] "Rise of the Drones," *Airman: Online Magazine of the United States Air Force*, available at http://airman.dodlive.mil/rise-of-the-drones.

[670] The armor-piercing AGM-114 was designed to kill Soviet tanks in the European theater. Munitions experts added a fragmentary sleeve around the missile's warhead in order to make Hellfires shot from Predators more effective against enemy personnel.

[671] Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture, School of Advanced Air and Space Studies Monograph, June 2007, 26.

[672] Ibid.

[673] Charles Duhigg, "The Pilotless Plane That Only Looks Like Child's Play," *New York Times*, 15 April 2007, available at http://www.nytimes.com/2007/04/15/business/yourmoney/15atomics.html.

asset in the Global War on Terror, accumulating more combat hours than any other platform in the Air Force's inventory.

As chief, Jumper also ordered the purchase of the MQ-9 Reaper, the Predator's bigger, more lethal cousin (originally called the Predator B). General Atomics used its own money to produce a prototype. To market the plane to the Air Force, Thomas Cassidy simply visited Jumper in his office, dropping off a video tape highlighting the plane's capabilities. Shortly thereafter, Jumper committed the Air Force to purchase the first two production aircraft.[674] This was a pivotal decision because it committed the Air Force to purchase a follow-on system, something the Air Force had never done before with its drone programs.

Gates Accelerates UAS Adoption and Imposes Tradeoffs

When T. Michael Moseley succeeded Jumper in September 2005, the Air Force's unmanned aircraft fleet had grown so rapidly that the service was struggling to find ways to staff its unmanned cockpits. Furthermore, funding the ever-expanding fleet of unmanned aircraft was starting to significantly squeeze the Air Force's budget. Moseley, less visionary than some of his predecessors, was unwilling to chart a new future for the organization and was unwilling to cannibalize the service's manned aircraft, especially the F-22, to pay for more UAVs.[675]

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[674] Houston Cantwell, "RADM Thomas J. Cassidy's MQ-1 Predator: The USAF's First UAV Success Story," Air Command and Staff College Monograph, April 2006, 25.

[675] Like Moseley, both Fogleman and Jumper were also ardent F-22 supporters. It is interesting to speculate whether they too would have been less visionary in terms of their unmanned aircraft support when faced with the same tradeoff decisions as Moseley. It certainly may be easier to be a visionary leader early in the life cycle of a technology because few tradeoffs are required, which is one of the reasons why *disruptive innovation* typically starts in a niche or peripheral role and then blossoms with time to become core (see Chapter 2). It is easier to gain a foothold in a peripheral market because those in power care less about peripheral systems and are less challenged by the adoption of disruptive technology to fulfill a niche role.

In December 1996, Moseley abruptly cancelled a program that Jumper had initiated to create a new Air Force specialty code for UAV professionals.[676] Under Jumper's direction, three non-rated officers were selected to complete a modified training program to test the viability of sending officers to fly the Predator without first sending them through traditional flight school. Without explanation, Moseley, intervened, prevented the three officers from reporting to operational Predator squadrons after completing their training, and gave them all new assignments.[677]

Robert Gates defended the F-22 when he became Secretary of Defense in December 1996, but after listening to his field commanders in Iraq and Afghanistan, he was convinced of the necessity of charting a new defense course.[678] As a result, Gates pressed the Air Force to rapidly expand the rate at which it was fielding unmanned systems. Moseley resisted, publically disagreeing with the secretary of defense's plans to get the Air Force to modify its force structure to rely more heavily on unmanned aircraft.[679] Moreover, Moseley refused to sacrifice the fighter community's most treasured aircraft, the F-22, to pay for the plus-up in the unmanned fleet.[680] Indeed, he went to great lengths to prevent the secretary of defense from ending F-22 production. Moseley initiated a program to cut nearly 40,000 airmen to free up

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676 The "17XX" program was actually Jumper's second UAV manning initiative. Originally, he called for a new career field called the "combat systems officer" (CSO), which would have been an offshoot of navigator training. The initiative, however, did not gain momentum and was not implemented.
677 Les McPeak, interview with the author, June 2009. Lieutenant Leslie McPeak (no relation to the former chief of staff) had already successfully completed the Predator training program when Moseley decided to abruptly end the new career field. Prevented from reporting to his operational Predator squadron, McPeak was instead sent to become a missile launch officer. It is unclear how far along Captain Thomas Bean and Captain Oswald Bonilla, the other two selected for the new career field test, were in the program or whether they finished training, but they too were given new assignments.
678 Rebecca Grant, "The Evolution of Airpower Under Gates," *Air Force Magazine*, February 2011, 54-55.
679 Gates had a similar frustrating experience with the Air Force when he served as the director of the Central Intelligence Agency in the early 1990s. McPeak, then Air Force chief, reportedly refused to support building a spy drone that Gates championed because "it didn't have a pilot" [Mark Thompson, "Why the Air Force Bugs Gates," *Time*, 21 April 2008, available at http://www.time.com/time/nation/article/0,8599,1733747,00.html].
680 Rebecca Grant, "The Evolution of Airpower Under Gates," *Air Force Magazine*, February 2011, 53.

money so the Air Force could internally re-program funds to continue F-22 production, thereby circumventing Gates's intentions to orchestrate a remix of airpower.[681] Moseley did this at a time when the service's manpower estimate to Congress indicated the service needed more, not fewer personnel.[682] What was worse, Moseley continued to lobby Congress for more F-22 funding after Gates made clear his funding priorities lay elsewhere. Incensed over the disobedience, Gates fired Moseley.[683]

Gates then appointed Norton Schwartz, the first non-fighter or bomber pilot to lead the service since its inception after World War II, as Moseley's replacement.[684] Gates made the unorthodox choice because he wanted to dramatically reorient the leadership of the Air Force.[685] In Schwartz, Gates perhaps hoped to find a uniformed partner more willing to lead change and help him alter the Air Force's structure. Schwartz obliged, writing an op-ed that

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681 "Air Force generals wagered that cuts in manpower would free up money to buy more planes. As the costs of producing new F-22 Raptor fighter jets climbed, the service banked on cutting personnel costs to make more room in its budget for the ever-pricier planes" [Scott Canon, "Air Force, Navy Downsizing Troops to Pay for Hardware," *Free Republic*, 14 November 2007, available at http://www.freerepublic.com/focus/f-news/1925589/posts].

682 Gates ended the personnel cut shortly after firing Moseley. Michael Hoffman, "Gates: No More Cuts to Air Force Personnel," *Air Force Times*, 9 June 2008, available at http://www.airforcetimes.com/news/2008/06/airforce_drawdown_ends_060908w.

683 There are a lot of similarities between the Air Force's struggle to build the XB-70 and its struggle to build more F-22s. Although General Thomas White, the fourth Air Force chief, turned the service's priorities up-side down (i.e., moving ICBMs from the bottom of its priority list to the top), he nonetheless remained a manned bomber supporter. He championed building the XB-70, but after Eisenhower decided it should be canceled, White told Congress he "accepted" the decision. General LeMay, White's successor, however, did not. He openly disagreed with the Kennedy administration's decision to cancel the XB-70 and told Congress it was a mistake. Kennedy considered firing LeMay, but decided otherwise because there would have been too much of an uproar. In the case of the F-22, both Fogleman and Jumper were ardent F-22 supporters, but in the end neither openly challenged their civilian bosses over the decision to scale back the Raptor program. Moseley did, and it was a key factor in his dismissal.

684 Schwartz had been thought to be in line for retirement. His replacement as head of the U.S. Transportation Command had been announced months earlier [Robert Burns and Lolita C. Baldor, "Gates Recommends Schwartz as Next Air Force Chief," *USA Today*, 9 June 2009, available at http://www.usatoday.com/news/washington/2008-06-09-264532382_x.htm.

685 "Defense Secretary Robert M. Gates took action to dramatically reorient the leadership of the Air Force, calling for the nomination of the first non-fighter or bomber pilot to lead the service since its inception after World War II. His recommendation that Gen. Norton A. Schwartz, who began his military career as a cargo pilot, be nominated by President Bush as Air Force chief of staff marks a significant shift in Air Force leadership [Julian E. Barnes and Peter Spiegel, "A Different Type of Air Force Leader, *Los Angeles Times*, 10 June 2008, available at http://articles.latimes.com/2008/jun/10/nation/na-schwartz10].

told the Air Force that the fight was over and that the service needed to "move on."[686] "Buying more F-22s means doing less of something else," Schwartz stated.[687] He went on to say that the $13 billion saved in lieu of buying 60 additional Raptors could be better used to fund higher priorities, among them unmanned aircraft.[688] Not surprisingly, Schwartz is seen by die-hard senior Air Force officers as a complete creation of Gates.[689] When rumors circulated that Schwartz was leaving his post early, an insider trade publication observed, "The pilot coterie may be quite happy to see him go [because of] his unrelenting efforts to remake the service's culture and get his people to focus on their joint contributions and to earn respect by flying drones, not just fighters."[690]

Although it is an overstatement to claim that Gates has dramatically reshaped the Air Force, he has placed the service on a path to change.[691] In addition to ending production of the F-22 and forcing regime change within the Air Force, Gates cancelled the Air Force's Next Generation Bomber pending a study to see whether it should be unmanned, sent 250 fighters into early retirement to fund continued UAS expansion, and more than doubled the number of unmanned aircraft in the Air Force's inventory. Additionally, Gates ensured the 2010 Quadrennial Defense Review contained a commitment to purchase 372 additional MQ-9 Reapers. In making the announcement, Gates proclaimed, "[UAVs will be] an increasing part of the Air Force arsenal going forward."[692] During congressional testimony, Schwartz echoed his

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686 Michael Hoffman, "AF Leaders: F-22 Cuts a Matter of Priorities," *Air Force Times,* 13 April 2008, available at http://www.airforcetimes.com/news/2009/04/airforce_F22_oped_041309w.
687 Ibid.
688 Ibid.
689 Colin Clark, "Hoss Leaving, Schwartz Replacing," *DoD Buzz*, 9 August 2010, available at http://www.dodbuzz.com/2010/08/09/hoss-leaves-schwartz-replaces.
690 Ibid.
691 Rebecca Grant, "The Evolution of Airpower Under Gates," *Air Force Magazine*, February 2011, 53.
692 Ibid, 57.

civilian boss's assessment, declaring, "This is an inflection point … The trend lines are unmistakable that the United States Air Force will be an increasingly unmanned aviation service."[693]

Exponential Growth in the Army

The Army experienced far less internal resistance than the Air Force in its adoption of unmanned aircraft. Although the Aquila debacle chastened Army unmanned acquisition efforts, the service acquired a handful of RQ-2 Pioneers, a system with Israeli roots, a few months prior the first Gulf War in 1991. Deployed on a trial basis, the Army's RQ-2s completed 300 missions, demonstrating potential as a reconnaissance tool.[694]

Excited by the promising result, the Army, as noted earlier, provided aircrew for the Predator ACTD. Under pressure from Ron Fogleman, Army leaders agreed to bequeath the Predator to the Air Force, but they did so while reserving the right to buy UAVs, including the Predator, in the future if the Air Force did not deliver on its promise for more support.[695]

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[693] Statement of General Norton A. Schwartz, Chief of Staff, U.S. Air Force, in Senate, Committee on Armed Services, *Hearing to Receive Testimony on the Department of the Air Force in Review of the Defense Authorization Request for Fiscal year 2010 and the Future Years Defense Program*, 21 May 2009, 11, http://armed-services.senate.gov/Transcripts/2009/05%20May/09-35%20-%205-21-09.pdf.

[694] Source: *U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035*, June 2010, 60, available at http://www.fas.org/irp/program/collect/uas-army.pdf. The U.S. Navy first took delivery of the nine RQ-2 systems, which includes both ground equipment and aerial vehicles) in July 1986. The Navy initially placed the Pioneer aboard battleships to provide gunnery spotting. Its mission later evolved into reconnaissance and surveillance, primarily for amphibious forces. Like the Predator, the RQ-2 has Israeli roots. Israel Aircraft Industries and AAI Corporation jointly developed the aircraft. The Army received their first Pioneers in March 1990, just in time for the first Gulf War five months later.

[695] Thomas Ehrhard suggests that the Army agreed to give the Predator program to the Air Force because its leaders thought they could appropriate control of the program without having to pay for it through the design of the UAV Tactical Control System (TCS), a command and control system [Thomas Ehrhard, *Air Force UAVs: The Secret History* (Arlington, VA: Mitchell Institute Press, 2010), 52]. Through TCS, Ehrhard asserts that the Army believed it would gain the capability to take control of the drone's flight and sensors, "turning the Air Force into little more than an agency for Predator funding, takeoff, and landing" [Ibid]. Interestingly, this has happened, to a degree, with Gorgon Stare, the latest sensor put on the Reaper. The Gorgon Stare pod is controlled independent of the Reaper's crew by a two-member ground team working from a dedicated control station that fits on the back of a Humvee

Aside from ceding the Predator to the Air Force, the Army continued its UAV research unabated. In 1996, the year that the Air Force took over the Predator program, the Army took delivery of seven RQ-5 Hunter systems as part of a low-rate initial production (LRIP) contract, three of which were used for doctrine development and exercise and contingency support. The next year, it sent the Hunter to fly in a war game at the U.S. Army National Training Center at Fort Irwin. The system performed so well that Major General Paul Kern, commander of the 4th Infantry Division, told Army Chief of Staff General Dennis Reimer, "I will give up a tank battalion for a UAV company."[696] In 1999, the Army deployed the Hunter to Macedonia in support of NATO forces in Kosovo, part of the former Yugoslavia. During OPERATION ALLIED FORCE, Hunters flew over 600 flight hours, providing useful imagery and real-time data.

Also in 1999, the Army contracted to buy the RQ-7 Shadow, AAI Corporation's follow up to the Pioneer. The service took delivery of its first low-rate initial-production systems in 2002. A year later, full-scale production systems started rolling off the assembly line, and the Army immediately deployed them in support of the 2003 invasion of Iraq. Over the next several years, the Army, in a move to strengthen its airpower self-sufficiency, would take delivery of 364 RQ-7 Shadows.[697] It also purchased two dozen RQ-5Bs, an improved version of the Hunter to supplement its UAV fleet.[698]

[Richard Whittle, "Gorgon Stare Broadens UAV Surveillance," *Aviation Week*, 3 November 201, available at http://www.aviationweek.com].

[696] Bill Yenne, Birds of Prey: Predators, Reapers and America's Newest UAVs in Combat (North Branch, MN: Specialty Press, 2010), 41.

[697] Jeremiah Gertler, "U.S. Unmanned Aerial Systems," Congressional Research Service Report (R42136), 3 January 20012, 8, available at http://www.fas.org/sgp/crs/natsec/R42136.pdf.

[698] The United States Army Homepage, "Army Unmanned Aerial Systems Hits One Million Flight Hour Milestone," STAND-TO! Edition: Tuesday, May 25, 2010, http://www.army.mil/standto/archive/2010/05/25. "The army has been quietly building its new 'army air force' for a while" [James Dunnigan, "The Growing Threat of the U.S. Army Air Force," *Strategy Page*, 18 April 2010, available at http://www.strategypage.com/dls/articles/The-Growing-Threat-Of-The-U.S.-Army-Air-Force-4-18-2010.asp].

In 2004, the Secretary of Defense canceled the Army's Comanche helicopter program. The Army had been trying to build the Comanche, a stealthy gunship, for 22 years but cost overruns led to six program restructurings.[699] The Army used the opportunity to reinvest money earmarked for the Comanche to fund its Extended-Range/Multi-Purpose (ER/MP) Unmanned Aerial Vehicle System program. As part of the ER/MP program, the Army outlined plans to acquire 48 I-Gnat and Warrior Alpha aircraft, variations of the Predator offered by General Atomics.[700] The acquisition meant that the Army and the Air Force would essentially fly the same platform built by the same manufacturer from the same runways over the same "kill boxes" in the same airspace performing the same mission for the same customers in Iraq and Afghanistan.

The Air Force cried foul. It saw the Army's plans as an encroachment on its airpower responsibilities. The junior service also thought the Army was breaking its earlier promise to cede the Predator program to its control. The Air Force, hoping to frustrate the Army's plans, proposed in 2007 to become the Department of Defense's "executive agent" for unmanned aircraft. The proposal would have placed the Air Force in charge of all current and future medium- and high-altitude UAVs.

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[699] The Army had planned to buy 1,213 Comanches, but the planned purchase was cut the buy to 650 after the cost of building the complex design skyrocketed (see discussion in Chapter 2 on the vicious cycle of ever-increasing cost and complexity related to sustaining innovations).

[700] Sandra I. Erwin, "Air Force to Army: There Are Better Ways to Deploy Surveillance Aircraft," *National Defense Magazine*, January 2010, http://www.nationaldefensemagazine.org/archive/2010/January/Pages/AirForcetoArmyThereAreBetterWaystoDeploySurveillanceAircraft.aspx.

The Army vociferously objected to what it saw as a power grab.[701] Influenced by its experience when the Air Force controlled its rotary-wing acquisitions (see Chapter 4), the Army feared having its UAV buying power taken away would stifle innovation and result in systems that did not meet the service's airpower needs.[702] Army leaders claimed it was necessary to build an organic unmanned air force because the Air Force was neglecting the airpower needs of its troops in Iraq and Afghanistan.[703] Complaining that the Air Force had fulfilled only half of its ground commander's requests for the surveillance aircraft, the Army publically accused the Air Force of "not pulling its weight."[704] Army officers, citing anecdotes of Air Force aircraft flying off in the middle of operations to perform other previously scheduled tasks, charged that the Air Force could not be counted on in the heat of battle.[705] They also claimed that relying on the Air Force had "unequivocally" cost the lives of ground troops.[706] Deputy Defense Secretary

[701] Megan Scully, "Pentagon rejects Air Force bid to control UAV programs," *Government Executive*, 14 September 2007, available at http://www.govexec.com/defense/2007/09/pentagon-rejects-air-force-bid-to-control-uav-programs/25296.
[702] Ibid.
[703] Thom Shanker, "At Odds With Air Force, Army Adds Its Own Aviation Unit," *New York Times*, 22 June 2007, available at http://www.nytimes.com/2008/06/22/washington/22military.html?pagewanted=all.
[704] Ibid.
[705] Stew Magnuson, "Army to Air Force: We Won't Give Up Our Surveillance Aircraft," *National Defense*, February 2010, available at http://www.nationaldefensemagazine.org/archive/2010/February/Pages/ArmytoAirForceWeWon%E2%80%99tGiveUpOurSurveillanceAircraft.aspx. For example, Col. Gregory Gonzalez, the U.S. Army's Unmanned Aircraft System project manager, told reporters that he was in a command-and-control center in Afghanistan when insurgents nearly overran an outpost in the Hindu Kush Mountains. Eight soldiers lost their lives in the battle. Gonzalez told reporters that more lives would have been lost if not for an Army unmanned aircraft that came to the rescue. "Because the Army has a tactic to have direct support of these brigades, they were able to dynamically task some of our Army unmanned aircraft systems to find the enemy that was attacking those in the combat outpost," Gonzalez said. "Had it not been for that ability to immediately task those [Army unmanned] aircraft, we could have seen a much different outcome. And many of the soldiers who did come off of that [command outpost] alive, may not have" [Ibid]. Similarly, Timothy Muchmore, the director of the Army Quadrennial Defense Review, complained, "We've had two combat outposts overrun by superior forces [during the past year]. Those are losses that we consider unacceptable, because we couldn't see what was going on around the outposts" Sandra I. Erwin, "Army on a Fast Track to Build its Own High-Tech Air Force," *National Defense*, April 2010, available at http://www.nationaldefensemagazine.org/archive/2010/April/Pages/Armytobuilditsownairforce.aspx].
[706] Ibid.

Gordon England agreed with the Army's argument and after conferring with his boss, Robert Gates, rejected the Air Force's bid for executive agency.[707]

The decision opened the way for the Army to continue expanding its UAV fleet and weaponize its drones. In 2010, the Army took delivery of the MQ-1C Grey Eagle, an improved version of the Predator that carries twice its ordnance and more internal payload.[708] The Grey Eagle flies 4,000 feet higher and markedly faster than the Air Force's Predator. Plus, the Army is equipping its Grey Eagles with synthetic aperture radars, equipment that Air Force Predators do not carry. The Air Force only recently installed similar radars on its MQ-9 Reapers. The Army initially planned to field 132 Grey Eagles—11 systems, one for each of its divisions, which include five ground stations and up to 12 aerial vehicles)—but, subsequently bumped the number up to 13.[709] In 2011, it unveiled plans to increase number of systems from 13 to 31.[710]

In summary, over the last decade, unmanned aircraft experienced exponential growth within the Army. From three Hunters flying a relatively insignificant number of flight hours, the Army now operates more than 400 UAVs that fly over 25,000 flight hours each month.[711]

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707 Megan Scully, "Pentagon rejects Air Force bid to control UAV programs," *Government Executive*, 14 September 2007, available at http://www.govexec.com/defense/2007/09/pentagon-rejects-air-force-bid-to-control-uav-programs/25296.
708 The Grey Eagle was originally named the Sky Warrior.
709 "Sky-Warrior ERMP UAV System," *Defense Update*, available at http://defense-update.com/products/w/warriorUAV.htm.
710 See http://www.deagel.com/Unmanned-Combat-Air-Vehicles/MQ-1C-Sky-Warrior_a000125001.aspx.
711 Dyke Weatherington, "Future of Unmanned Aircraft Systems in a Fiscally Constrained Environment," available at http://www.ndia.org/Divisions/Divisions/SOLIC/Documents/Weatherington_slides_3-1-11.pdf. Note: the figures given do not include Class I UAVs such as the Raven. In total, the Army owns more than 4,000 UAVs [Ibid].

ASSESSING EXPLANATORY VALUE

The Insufficiency of Coté, Posen, and Rosen

Although insightful, the three standard political science theories put forth by Owen Coté, Barry Posen, and Stephen Rosen provide incomplete explanations for when and why the U.S. Air Force and U.S. Army adopted unmanned aircraft. Coté's theory has two components. First, he says interservice competition spurs innovation. Second, he claims civilian management style is the overriding determinant of competitive and cooperative patterns of service behavior.[712] Coté's theory matches the historical record when it comes to the first component, but not the second.

In 1995, the Predator, still in a prototype stage of development, demonstrated combat utility after being deployed in support of combat operations over the former Yugoslavia. At the time, the Predator was under the operational control of the Army. After it became inescapably apparent that the system would be fielded, the Air Force maneuvered to wrest control of the system from the Army. The Air Force intervened to gain control of the Predator, in part, because of its doctrinally based aversion to the Army flying fixed-winged aircraft. Prior to the Air Force's bid to become the lead service for the Predator, the service's sole contribution to the program had been to send a single B-52 pilot to fly the air vehicle.[713] Thus, interservice competition did indeed play a role.

Nevertheless, the problem with using Coté's theory to explain the adoption of unmanned aircraft is that UAVs experienced exponential growth precisely when his model

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[712] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 351. See also p. 339-340.
[713] Sean Frisbee, "Weaponizing the Predator UAV: Toward a New Theory of Weapon System Innovation," School of Advanced Air & Space Studies Monograph, June 2004, 54-55.

suggests interservice competition and hence innovation should have been dead.[714] First, Coté claims interservice competition essentially ceased with the appointment of General Earle Wheeler as chairman of the joint chiefs in 1964.[715] He says the services banded together and muted interservice disagreement in order to thwart Secretary of Defense Robert McNamara's centralized management style.[716] Coté asserts that practice continues today, thus minimizing the influence of interservice competition. Second, Congress's push for "jointness" through the enactment of the 1986 Goldwater-Nichols Act created strong systemic disincentives for interservice competition.[717] In fact, the Joint Requirements Oversight Council (JROC), a body created by the Goldwater-Nichols Act, swiftly mediated the interservice competition over the Predator, awarding ownership of the Predator to the Air Force.[718] Third, the Predator emerged at a time when Congress centralized control and management of the reconnaissance budget under the Defense Airborne Reconnaissance Office (DARO).[719] Using Coté's theory, one would expect the services to react to this "grand experiment in civilian intervention and centralized control" in the same way Coté says they did when Secretary of Defense Robert McNamara introduced centralized planning, programming, and budgeting procedures to strengthen civilian

[714] Until the Predator, interservice rivalry rarely came into play, in large part due to the discrete types of UAVs pursued by each service [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 571].
[715] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 18.
[716] Ibid, 351. See also p. 339-340.
[717] Harvey M. Sapolsky, "Interservice Competition: The Solution, Not the Problem," *Joint Forces Quarterly*, No. 15, Spring 1997, 51.
[718] The Army chief of staff ceded Predator in exchange for a commitment by the Air Force leadership to support Army reconnaissance requirements [Sean Frisbee, "Weaponizing the Predator UAV: Toward a New Theory of Weapon System Innovation," School of Advanced Air & Space Studies Monograph, June 2004, 56].
[719] The establishment of the DARO "can be seen as a deepening of OSD and congressional intervention into an area the services had neglected" [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 510].

management control back in 1964—by banding together.[720] This should have stifled innovation, but the Predator managed to break free from an established pattern of interservice deference over unmanned aircraft technology exactly when Coté's theory suggests it should not have happened.

Posen suggests the armed services seldom innovate on their own initiative, and as a result, change comes through energetic civilian intervention.[721] Posen's work is perceptive, but like Coté's, it also does not fully explain the development and adoption of unmanned aircraft. Using Posen's model, one might conclude that since the Predator emerged under the auspices of DARO, an office established by Congress, that civilian intervention was the source of innovation. But, civilian intervention generally served to dampen the services' affinity for the UAV.[722] Thomas Ehrhard concludes, "In the final analysis, the vanguard of the UAV proletariat [a term he uses to describe civilian UAV proponents in both Congress and the Office of the Secretary of Defense] proved no more, and arguably less capable, of UAV development than the services."[723]

Since Ehrhard's observation in 2000, civilian intervention played a role in accelerating the adoption of unmanned aircraft. As noted in the narrative above, Secretary of Defense Robert Gates helped accelerate the expansion of the U.S. military's UAV fleet. When Gates took over as the 22nd Secretary of Defense in 2006, the U.S. Air Force was flying twelve unmanned combat air patrols (CAPs) in support of OPERATION ENDURING FREEDOM and

[720] Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 496.
[721] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 44-45.
[722] Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 602.
[723] Thomas Ehrhard, Air Force UAVs: The Secret History (Arlington, VA: Mitchell Institute Press, 2010), 57.

OPERATION IRAQI FREEDOM (see Figure 14).[724] During his five-year tenure, the number of daily CAPs flown by unmanned Air Force aircraft ballooned to sixty, a 500% increase.

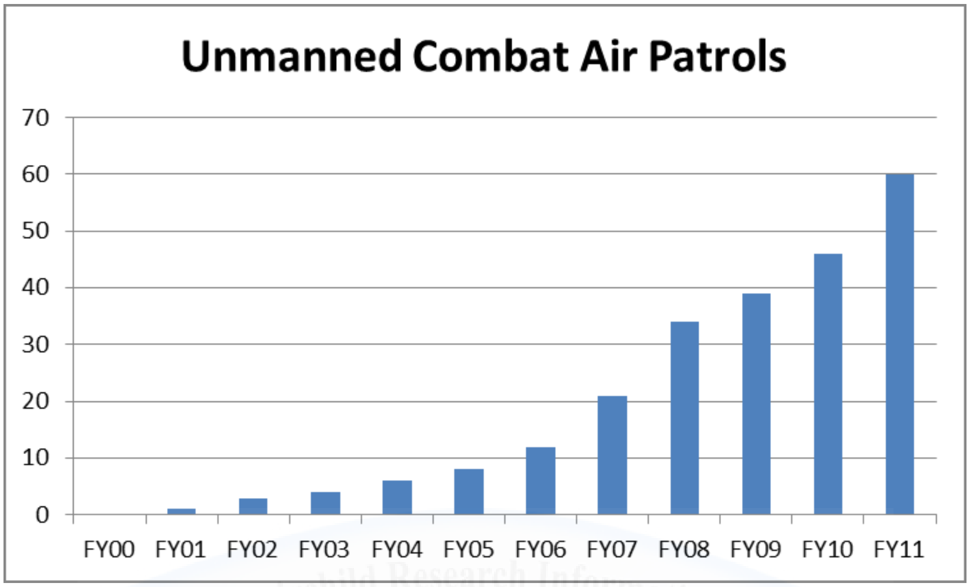

FIGURE 14 – Unmanned Combat Aircraft Patrols (FY00 – FY 11)[725]

Gates's emphasis on unmanned aircraft, although pivotal, does not tell the whole story behind the adoption of unmanned aircraft. Gates took over as Secretary of Defense more than a decade after the Predator made its combat debut. By that time, the adoption of unmanned aircraft was already underway. From less than a handful in 2000, the Air Force inventory of Predators expanded rapidly, numbering sixty seven by the end of 2005. Thus, an established pattern of rapid growth existed before Gates took office (see Figure 15).[726]

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[724] Under Donald Rumsfeld, Gates's predecessor only 25% of the Pentagon's UAV fleet was being used in the Central Command (CENTCOM) area of operations. Since 2006, UAV operations have exploded from 165,000 hours per year to over 550,000 hours per year [Bill Sweetman and Paul McLear, "Gates's Legacy Mixed," *Aviation Week*, 6 January 2011, available at http://www.aviationweek.com/aw/jsp_includes/articlePrint.jsp?headLine=Gates'%20Legacy%20Mixed&storyID=news/dti/2011/01/01/DT_01_01_2011_p39-276264.xml].

[725] Source: David A. Deptula, Air Force ISR in a Changed World: Changing Paradigms While Optimizing 'Low Density' to Meet 'High Demand" (presentation, Headquarters U.S. Air Force, Washington, DC, 30 March 2010).

[726] Air Force Historical Studies Office, Bolling Air Force Base, MD, e-mail to author, 9 June 2011 (original source: "CAF Force Structure spreadsheets"). Inventory statistics underestimate the pace at which the Air Force was acquiring Predators. By 2005, the Air Force had acquired more than a hundred Predators, but had lost a staggering

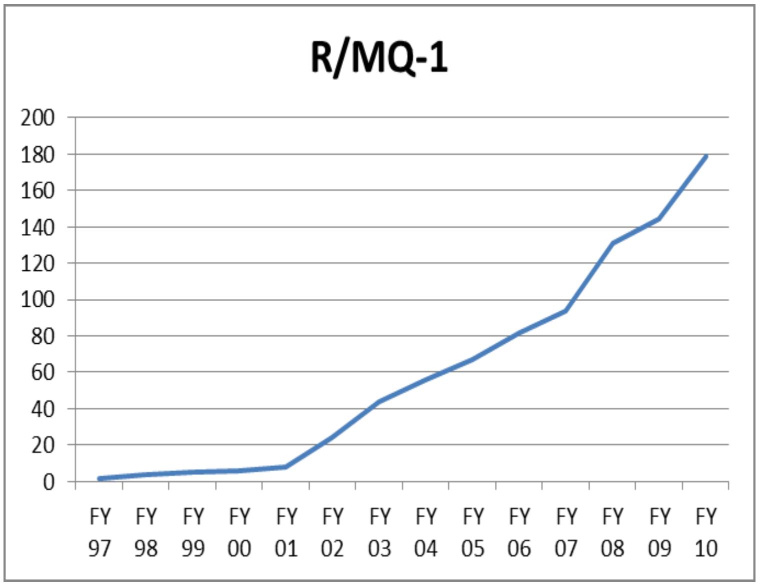

FIGURE 15 – U.S. Air Force R/MQ-1 Predator Inventory over Time[727]

Giving Gates, a civilian, sole credit for the adoption of unmanned aircraft neglects earlier contributions made by those in uniform. Specifically, generals Ron Fogleman and John Jumper deserve to share much of the credit. Fogleman embraced the Predator, stealing the program away from the Army, and taking it under his wing. Jumper, while serving as the United States Air Forces Europe commander, was instrumental in bringing the Predator to combat. Later, as the commander of Air Combat Command, he ordered a crash program to weaponize the Predator with AGM-114 Hellfire missiles. As part of the upgrade, Jumper directed replacement of the Predator's original camera with a Multi-Spectral Targeting System, which included improved television and infrared cameras as well as a laser designator. Without these crucial

number of aircraft (34) in training and combat-related mishaps since the start of the program. A breakout, by year, of Predator accident information is available from the Air Force's Safety Center website: http://www.afsc.af.mil/shared/media/document/AFD-080114-108.pdf).

[727] Inventory compiled from multiple sources, including records from the Air Force Association, the Air Force Office of the Comptroller, Air Force History Office, Air Force Safety Center, and General Atomics, the Predator's manufacturer. Note: the RQ-1 was the original reconnaissance version of the Predator. After the Air Force weaponized the Predator, it changed the aircraft's nomenclature to the MQ-1B to reflect its multi-role capability.

upgrades, the Predator would have been much less useful, and ground commanders in Iraq and Afghanistan may not have developed an insatiable demand for support from that weapon system.[728] Additionally, as chief, Jumper presided over the initial growth stages of the Predator.

Lastly, there are at least three reasons why Rosen's intraservice innovation model does not fully explain the development and adoption of unmanned aircraft. First, Rosen says innovation only occurs slowly—indeed, "only as fast as young officers rise to the top"—but his claim does not match the historical record when it comes the pace of adoption of unmanned aircraft.[729] Instead of the generationally slow pace Rosen predicts, unmanned aircraft have witnessed what has been described as "meteoric" and "explosive" growth since 2001.[730] General Atomics, the Predator's manufacturer, literally could not roll birds off its assembly line fast enough to meet demand.

Second, Rosen says civilian intervention is ineffectual, yet Gates's unmanned aircraft advocacy had a significant impact on facilitating change within the U.S. Air Force. Gates overcame opposition and stonewalling from the service's senior leadership to engineer an accelerated expansion of the Air Force's unmanned fleet.[731] General T. Michael Moseley, who

[728] Lawrence Spinetta, "The Rise of Unmanned Aircraft: Do Earthbound Aviators Represent the Future of Aerial Warfare?" *Aviation History*, January 2011, 30.
[729] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 105.
[730] "The U.S. military Unmanned Aerial Vehicles (UAV) market has witnessed a meteoric growth over the past decade [Market Research Media, "U.S. Military Unmanned Aerial Vehicles (UAV) Market Forecast 2010-2015," April 2011, available at http://www.marketresearchmedia.com/2010/04/09/unmanned-aerial-vehicles-uav-market]. "UAS have experienced explosive growth in recent history …" [U.S Air Force, *United States Air Force Unmanned Aircraft Systems Flight Plan 2009-2047*, available at http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA505168].
[731] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 11. Rosen cites the case of how the Army successfully resisted President Kennedy's orders to develop a counterinsurgency capability as evidence of how the services hold the trump card in the innovation process. He writes, "The classic example … can be found in the failure of the U.S. Army to develop army-wide

took over as Air Force chief from Jumper in 2005, resisted Gates's request to field more unmanned aircraft CAPs faster. Moseley publically complained that all those extra flight hours were turning the roboplane's remote pilots into virtual "prisoners."[732] Instead of embracing the transition to unmanned aircraft, Moseley continued to backchannel lobby Congress for more F-22 fighter jets after Gates curtailed the program and made it clear the administration's acquisition priorities were to field more unmanned aircraft systems faster to support ground commanders in Iraq and Afghanistan.[733] In April 2008, Gates expressed his frustration with the Air Force leadership while speaking to students at Air University, Maxwell Air Force Base:

> My concern is that our services are still not moving aggressively in wartime to provide resources needed now on the battlefield. I've been wrestling for months to get more

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capabilities for counterinsurgency even after being personally ordered to do so by the president. John F. Kennedy held a meeting with senior military officers to make clear his personal interest in counterinsurgency, and followed up on the meeting by creating a committee on which his brother Robert sat. Nonetheless, the army, because it believed in the superiority of conventionally trained infantry and that conventional wars would continue to dominate the army's strategic requirements, effectively blocked the shift to counterinsurgency while giving lip service to the president's orders" [Ibid,. 11]. But, citing one example of a situation when an armed service resisted civilian intervention successfully does not mean, as Rosen implies, that civilian intervention is always ineffective. Against fierce opposition from Air Force Chief of Staff Curtis LeMay, Kennedy successfully killed the XB-70 program. Kennedy helped orchestrate the transition from manned nuclear bombers to ICBMs (see chapter 3). The principle of civilian control of the U.S. military means civilians, not those in uniform are the ultimate arbiters of military strategy, the budget, the type of weapon systems purchased, etc. If they choose to use the power (i.e., choose to expend the political capital), civilians, not uniformed leaders, hold the trump card in the innovation process. General T. Michael Moseley found that out when Gates summarily fired him for obstructing the growth in unmanned aircraft and for backchannel congressional lobbying in support of more F-22s after Gates directed the program to be curtailed. Unlike LeMay, a war hero, who survived repeated altercations with the Kennedy and Johnson administrations, Moseley did not have the same congressional support to get away with vocal and public disagreement with his civilian boss. Schwartz, Moseley's successor, ended any further disagreement, essentially telling the Air Force to move on and stop re-attacking on the F-22 issue. See Peter Feaver's *Armed Servants: Agency, Oversight, and Civil-military Relations* for an interesting take on how the military works or shirks the orders of its civilian masters.

732 Kevin Drum, "The Air Force Takes Center Stage," *Washington Monthly*, 9 June 2008, available at http://www.washingtonmonthly.com/archives/individual/2008_06/013877.php.

733 "Attack of the Drones," *Newsweek*, 19 September 2009, http://www.newsweek.com/2009/09/18/attack-of-the-drones.html. See also Amy Butler and David A. Fulghum, "Wynne, Moseley Sacked in USAF Shakeup," *Aviation Week*, 5 June 2008, http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=defense&id=news/SACK06058.xml&headline=Wynne,%20Moseley%20Sacked%20in%20USAF%20Shakeup.

intelligence, surveillance and reconnaissance assets into the theater. Because people were stuck in old ways of doing business, it's been like pulling teeth.[734]

Gates lectured, "While we've doubled [unmanned surveillance] capability in recent months, it is still not good enough."[735] Two months later, the secretary of defense took the unprecedented step of firing both Moseley and Michael Wynne, the secretary of the Air Force. Gates publically cited problems in maintaining nuclear surety as the reason for their dismissal, but that was likely just an excuse to fire the pair over perceived intransigence over his order to field more unmanned aircraft CAPs quickly.[736] To encourage dramatic change, Gates replaced Moseley with General Norton Schwartz, the first chief to come from a background other than fighters or bombers.[737]

Third, Rosen's hypothesis suggests the creation of a new promotion path to senior ranks is an indispensable prerequisite for innovation, but unmanned aircraft experienced rapid growth without the creation of a new promotion path. In fact, the Air Force staffed the Predator program with, in the words of one commander, the "sick, lame, or lazy."[738] Stated

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[734] Michael Hoffman, "Gates Issues Call for More UAVs, Fresh Thinking," *Defense News*, 21 April 2008, available at http://www.defensenews.com/story.php?i=3490138.
[735] Mark Thompson, "Why the Air Force Bugs Gates," *Time*, 21 April 2008, available at http://www.time.com/time/nation/article/0,8599,1733747,00.html. The Air Force had delivered, albeit begrudgingly, over twice the unmanned capability eighteen months before the planned department of defense record program of record, yet that was woefully inadequate to satisfy an explosion in demand [Lieutenant General David Deptula, Deputy Chief of Staff for Intelligence, Surveillance, and Reconnaissance, "The Indivisibility of Intelligence, Surveillance, & Reconnaissance (ISR)" (presentation, Headquarters U.S. Air Force, Washington, DC, 10 December 2008)].
[736] An accidental shipment of nuclear fuzes to Taiwan gave Gates political cover to fire the Air Force leadership. The main reason behind their dismissal was perceived slowness in getting more UAS to Iraq and Afghanistan, not to mention back-channel congressional lobbying for the F-22 Raptor after Gates canceled the program [Noah Shachtman, "Air Force Chief, Secretary Resign," *Danger Room: What's Next in National Security*, 5 June 2008, available at http://www.wired.com/dangerroom/2008/06/breaking-air-fo/].
[737] Schwartz flew various versions of the C-130. It is worth noting that a non-pilot has never made it to the Air Force's top leadership spot since the service's inception more than 60 years ago.
[738] The quote is from an interview with Lieutenant Colonel Brian Bergdahl, commander of the 15th Reconnaissance Squadron, an unmanned aircraft squadron referenced on page 3 of "UAVs-Building a More Credible Force," an unpublished paper available at http://www.spyflight.co.uk/uavops2.doc. The Air Force has staffed the Predator with a hodgepodge of personnel from a mix of backgrounds. In addition to staffing UAS with pilots from cargo/tanker,

differently, the Air Force staffed the program in an ad hoc fashion with non-volunteers who mostly consisted of outcasts and poor performers from other aviation communities as well as medically disqualified pilots. In a 2008 speech, Schwartz admitted that there was a "stigma" associated with unmanned aircraft assignments.[739] Furthermore, he acknowledged that Air Force personnel policies had turned the UAV community into a "leper colony."[740] Not surprisingly, the community has suffered lower promotion rates when compared with other communities.[741]

Exactly opposite to the sequence of events that Rosen's theory suggests should occur, the Air Force defined and established an unmanned aircraft career specialty in 2011, well after the technology had experienced rapid growth.[742] Fast-paced growth meant that the UAV community ballooned into the second largest group of aviators in the Air Force—only the F-16

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fighter, bomber, and helicopter communities, the Air Force also started sending pilots direct from pilot training as well as experimenting with a new Beta Test program in which UAS pilots bypass traditional Air Force pilot training in favor of an alternative path that includes less intensive airborne flight training.

739 Michael Hoffman, "Hundreds of Reaper, Predator Pilots Needed," *Air Force Times*, 29 September 2008, available at http://www.airforcetimes.com/news/2008/09/airforce_uav_pilots_092908w/.

740 Ibid.

741 There are a number of reasons being sent to an unmanned aircraft assignment hurt an officer's promotion opportunities. First, the assignment carried a stigma because it was staffed principally with poor performers. Second, the operational tempo was so great that officers were not allowed to leave. While their peers were allowed to attend professional military education and fill staff assignments, both vital for career advancement, unmanned aircraft pilots were stuck flying in the same duty for years without the opportunity to change assignments. Third, after spending years in an unmanned cockpit, the few officers who were allowed to return to their primary weapon system (e.g., F-15 pilot) were years behind their peers in experience, flight leadership, etc.

742 "A 2007 analysis … showed that of all USAF active and retired general officers, two have UAS experience noted in their biographies. How many note experience in the F-22, a program which became operational years after the Predator? Seventeen" [Timothy Schultz, *UAS Manpower: Exploiting a New Paradigm* (Maxwell Air Force Base, AL: Air Force Research Institute, 2009), 56]. One of the two was Brigadier General Frank Gorenc, A career F-15 pilot, Gorenc was one of the very few senior officers interested enough in unmanned aircraft to get checked out to fly the Predator. He did so while he was a Colonel deployed to Balad Air Base, Iraq. In an interview, Gorenc acknowledged the "cultural stigma attached to flying UAVs" within the Air Force [Houston Cantwell, "Beyond Butterflies: Predator and the Evolution of Unmanned Aerial Vehicles in Air Force Culture, School of Advanced Air and Space Studies Monograph, June 2007, 82].

community has more pilots. Yet contrary to Rosen's hypothesis, innovation occurred without the creation of a new promotion path.[743]

The New, Cross-Disciplinary Framework Adds Value

Historical evidence from this case suggests the new, cross-disciplinary framework adds explanatory power. Answering the set of questions posed in the "Research Approach" section of Chapter 1, the following discussion summarizes that evidence.[744]

First, do changes in a state's security situation and interservice competition, the two factors identified in doctrinal innovation literature as drivers of innovation, sufficiently explain when and why the U.S. military adopted the UAV? Or, per this dissertation's central hypothesis, did the perceived attributes of unmanned aircraft also weigh heavily in leaders' decisions?

The perceived attributes of unmanned aircraft appear to have weighed heavily leaders' decisions to adopt UAVs, more so than changes in the nation's security situation and interservice competition. Prior to the Predator, technological immaturity meant unmanned aircraft offered lower relative advantage than alternatives. Of the approximately two dozen UAV programs the U.S. military pursued, none offered a worthwhile return on investment.[745]

[743] In a keynote speech at the 2008 Air & Space Conference, Schwartz announced a new UAV training program where the Air Force would fill a relatively small portion of UAV positions with crews who had not gone through undergraduate pilot training (UPT). The first "Beta Test" class graduated in September 2009. A new Air Force Specialty Code for unmanned pilots was created in 2011 [Michael Hoffman, "Hundreds of Reaper, Predator Pilots Needed," *Air Force Times*, 29 September 2008, available at http://www.airforcetimes.com/news/2008/09/airforce_uav_pilots_092908w/].
[744] The questions highlight key differences between Posen, Rosen, and Coté theories and the new, cross-disciplinary model proposed in this study.
[745] Thomas Ehrhard, *Air Force UAVs: The Secret History* (Arlington, VA: Mitchell Institute Press, 2010, 43.

Case in point, the Army's poured $1 billion into the Aquila, only to cancel the drone after it overwhelmingly failed program milestones. The Aquila's failure cannot be attributed to lack of development interest, effort, or funding; it was canceled because the program delivered a drone that performed poorly and was expensive. Similarly, the Lightning Bug cost far more and was less successful in gathering intelligence than the RF-4. At times, the drone yielded valuable intelligence, but not enough given the cost of operations to sustain Air Force interest in the program after the Vietnam War ended.

The Predator succeeded when previous UAV programs had failed because it benefited from the confluence of critical enabling technologies that occurred in the early 1990s. The Predator was the first UAV to capitalize on light-weight, low-cost GPS receivers, which eliminated a major driver of mission failure among earlier unmanned systems—inaccurate navigation. Satellite technology also allowed the Predator to cast off line-of-sight range limitations. Additionally, the Predator did not have to employ complex launch and recovery procedures because advancements in computer technology enabled "real time" control, thereby allowing it to operate from conventional runways. Furthermore, the Predator benefited immensely from the digital revolution; advances in computer and satellite technology allowed the Predator to push its real-time video feeds anywhere around the planet over the military's secure internet, providing unparalleled portability and distribution of intelligence.

The Predator also benefited from a string of early successes that boosted two important perceived attributes: trialability and observability. First, General Atomics delivered on its promise to fly a prototype within six months of being awarded the contract. Refreshingly, especially when one considers Army's experience with the Aquila, the Predator also came in

below budget and was relatively cheap. Second, the prototype showed immediate promise after canvassing reconnaissance targets at ROVING SANDS, the world's largest air and missile defense exercise. The Predator's performance encouraged leaders to send the drone into combat for a trial by fire. Third, although the Predator experienced some operational hiccups, it demonstrated utility flying missions over the former Yugoslavia and later Iraq and Afghanistan. The Predator did not compete directly against high-tech manned aircraft designed for high-end combat missions in major wars like the F-15 or F-16. Rather, it demonstrated utility locating targets for manned aircraft while performing persistent surveillance, a monotonous, dull, low-end, niche mission that champions of manned aircraft did not covet. It was able meet a need that traditional, manned, fixed-wing aircraft were not performing well, but did not initially threaten the established order.

The Predator's path to adoption, gaining a foothold performing a peripheral mission, helps explain how a lowly, propeller-driven drone powered by a four-stroke snowmobile engine managed to enter the inventory of the Air Force, an organization whose technological zeal traditionally favors faster, higher-flying, longer-ranged, sleek and modern jet aircraft. After the initial invasions of Iraq and Afghanistan, the need for lethality from above lessened and was superseded by the need for persistent surveillance, an essential counterinsurgency enabler. In fact, dropping mass quantities of bombs after the countries had been overrun would be counter-productive to stabilization efforts. The problem with using Cold War fighters and bombers to perform persistent surveillance is that their airframes are not optimized to perform the mission, nor are they integrated into collection networks. For example, supersonic fighters can fly ten times faster than a Predator, a useful quality in a high-end conventional conflict, but

that trait becomes a huge disadvantage when trying to watch a suspected terrorist hideout. High cruise speed invariably means a high rate of fuel consumption. At most, a manned fighter can orbit over a surveillance target for a couple of hours before it has to refuel. Even if airborne tankers are positioned nearby, it is untenable to expect pilots to fly more than six to eight hours a day on a sustained basis because of exhaustion. In contrast, a Predator regularly completes combat missions that last more than thirty hours. Its four-stroke snowmobile engine may seem weak, but it permits the glider-like aircraft to sip fuel and thus achieve sortie durations that are unachievable with current manned aircraft. Even the toughest, most battle-hardened fighter pilot with an iron bladder would not be able to regularly endure the physiological demands of a standard Predator mission. Fresh crews rotate in and out of the ground-control station as required with relative ease. Large, manned bombers staffed with multiple crews may be able to match the Predator's sortie duration, but that significantly adds to the complexity and cost of operations. For example, using the B-1, a big bomber built for big wars, in Iraq and Afghanistan is, according to a Brookings Institute fellow, a complete "waste of a plane:"[746]

> Every time the Air Force sends a B-1B bomber on a mission over [Iraq or] Afghanistan, it spends $720,000 in fuel, repair, and other costs. And when the plane comes back, it has to spend 48 hours being repaired for every hour it was in the air. All of which is double-crazy, because the bomber doesn't really drop bombs over Afghanistan any more, thanks to the military's airstrike restrictions. The B-1B just lingers over the country with a camera: a big Predator drone, at many, many times the price.[747]

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[746] Noah Shachtman, "The Air Force Needs a Serious Upgrade," *Wall Street Journal*, 15 July 2010, A17.
[747] Noah Shachtman, "How To: Get a New Air Force, Without Going Broke," *Danger Room: What's Next in National Security*, 15 July 2010, http://www.wired.com/dangerroom/2010/07/how-to-get-a-new-air-force-without-going-broke/#ixzz0uvDmJxHA.

Former Secretary of the Air Force Michael Wynne agrees: "If the B-1 is not dropping its load of ordnance, we should withdraw it, and use unmanned systems instead. They're much cheaper."[748]

The attributes of unmanned aircraft make the class of weapon particularly attractive for the Army. The Army has a strong incentive to lessen the extent to which it relies on the Air Force for airpower support, and unmanned aircraft allow it to bypass bureaucratic barriers associated with building an organic fixed-wing air force of its own. Moreover, unmanned technology allows the Army to gain access to fixed-wing combat aviation without the cost and training requirements associated with fielding advanced, fixed-wing, manned aircraft. The B-2 Spirit costs approximately $55,000 per hour to operate and the F-22 Raptor costs more than $19,000 per hour. When maintenance and support costs are also included, flying-hour costs for the B-2 and the F-22 approach $250,000 and $50,000, respectively.[749] In contrast, the hourly operating cost of the Army's Warrior Alpha is measured in the hundreds of dollars. Likewise, a comparison of fixed costs associated with buying manned versus unmanned aircraft is just as lopsided as the huge difference in marginal operating costs.[750] As noted earlier, one B-2 costs over $2 billion and one F-22 costs more than $36 million; the purchase price of one Warrior Alpha rings up at $4.5 million.[751] In terms of training costs, the Air Force spends more than $2.6 million to send each of its fighter pilots through a year-long Specialized Undergraduate Pilot Training (SUPT) and follow-on training programs; the Department of Defense estimates the full cost to train one officer with the requisite operational experience to fly traditional manned

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[748] Ibid.
[749] http://hatch.senate.gov/public/_files/USAFResponse.pdf
[750] http://usmilitary.about.com/library/milinfo/blafacrates.htm
[751] Government Accountability Office, "Defense Acquisitions: Assessments of Selected Major Weapon Programs" (GAO-06-391), March 2006, 67 available at http://www.gao.gov/new.items/d06391.pdf

aircraft is more than $9 million.[752] In contrast, the Army operates its UAS fleet principally with junior enlisted troops and trains them in nine weeks at a fraction of the price.[753]

The point is not to imply that an Army private flying a Warrior Alpha provides the same capability as an Air Force B-2 or F-22 pilot. Rather, it highlights how the Army does not require or need the full performance of aircraft designed to complete high-end missions favored by the Air Force.[754] Army doctrine attaches airpower to ground units, and the service is not interested in paying premiums to acquire expensive, deep-strike technology designed to penetrate near-peer competitor integrated air defenses for strategic targets. Even though the current generation of unmanned aircraft cannot match the performance of manned aircraft along dimensions traditionally valued by the Air Force, it provides "good enough" capability for the Army, especially supporting ground operations while flying in the permissive skies of Iraq and Afghanistan. In fact, certain aspects of unmanned technology, such as the ability to provide full-motion video while performing persistent surveillance, make it more compatible for the Army's airpower requirements than more capable manned platforms.

No doubt, changes in the nation's security situation, notably the conflicts in the former Yugoslavia, Iraq, and Afghanistan, influenced the adoption of unmanned aircraft. The conflicts provided venues for the Predator to demonstrate its effectiveness and fueled growth. The wars in Iraq and Afghanistan also aggravated army discontent over what it perceived as a lack of

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752 Government Accountability Office, "Military Personnel: Actions Needed to Better Define Pilot Requirements and Promote Retention" (GAO/NSIAD-99-211), August 1999, 3, available at http://www.gao.gov/archive/1999/ns99211.pdf. See also Michael Hoffman, "UAV Pilot Career Field Could save $1.5B," *Air Force Times*, 1 March 2009, available at http://www.airforcetimes.com/news/2009/03/airforce_uav_audit_030109.

753 It costs the U.S. Air Force $135,000 to train an unmanned aircraft pilot [Ibid]. The U.S. Army's course is shorter

754 Christensen calls this "low-end disruption" [Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution* (Boston, MA: Harvard Business School Press, 2003), 46-49]. When this occurs, disruptive technology enters the market and provides a product which has lower performance than the incumbent but which exceeds the requirements of certain segments, thereby gaining a foothold in the market [Ibid].

airpower support from the Air Force. Nevertheless, it would be a stretch to claim that changes in the nation's security situation have been the primary driver, to date, of unmanned aircraft innovation. Peacemaking operations in the former Yugoslavia did not present a clear and unambiguous threat to our nation's survival. The conflict was trivial in terms of a direct threat to American security. Moreover, the Predator's role was so inconsequential that it was able to rotate out of theater when winter arrived and then return the following year with minimal impact.[755] Similarly, the campaigns in Iraq and Afghanistan, although far from perfectly executed, did not constitute a military disaster that shocked the United States into adopting new weapons. Nor was the Predator's adoption a response to an enemy's technological demonstration, by test or combat-use, which was "sufficiently stark and frightening to shake civilians' faith in the ability of their own military organizations to handle it," something Barry Posen suggests may be a requirement.[756] The United States, along with Israel, an ally, pioneered the use of unmanned aircraft.

Similar to changes in the state's security situation, interservice competition also played a role in the adoption of the Predator, but the factor has not been the primary driver of UAV weapon system innovation. Competition from the Army helped nudge the Air Force to adopt the Predator; Ron Fogleman intervened to steal the program away from the Army, in part, because of his service's doctrinally based aversion to the Army flying fixed-winged aircraft. Nevertheless, interservice competition does not explain why the Air Force has pursued other

[755] The Predator's first deployment was to Gjader, Albania in support of Joint Task Force Provide Promise from July through November, 1995. The Predator unit rotated home for the winter and then redeployed to Taszar, Hungary in March 1996. Note: while some argued that U.S. participation in the conflict was essential to preserve the relevance of the North Atlantic Treaty Organization, an important element of American security, the conflict did not directly threaten our nation's security. Nor did the Predator's demonstration during the conflict prove "sufficiently stark and frightening" to cause civilians to intervene to force the military to innovate against their wishes [Ibid].

[756] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY, Cornell University Press, 1984), 77.

unmanned aircraft, like the Lightning Bug and the RQ-4, strategic reconnaissance UAVs, even though it faced little competition from the other services in performing that mission.[757] Similarly, interservice competition does not explain the Army's fairly consistent interest in unmanned aircraft. Nor does it explain why the Army poured a billion dollars into the Aquila during the 1980s while the Air Force effectively sat on the UAV sidelines. In summary, interservice rivalry considerations rarely affected the Air Force and Army's UAV development decisions.[758]

Second, was interservice competition, as Coté alleges, overwhelmingly a function of "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services"?[759] *Or, did the perceived attributes of unmanned aircraft also influence competitive and cooperative patterns of service behavior?*

The driving factor behind the emergence of interservice competition over the Predator was not, as Owen Coté's theory suggests, due to a change in civilian management style.[760] Rather, the perceived attributes of the Predator influenced the Air Force's decision to intervene and steal the program away from the Army. The Air Force sat on the UAV sidelines for two

[757] The Lightning Bug provides another example. The Air Force developed the Lightning Bug without facing interservice competition from any of the other services.
[758] Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 571. See also p. 599.
[759] Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 351. See also p. 339-340.
[760] To emphasize, interservice competition emerged precisely at a time when Coté's theory suggests it should have been dead. Coté says civilian management style is *the* overriding determinant of competitive and cooperative patterns of behavior among the services. Coté says centralized civilian control stifles innovation. But, the Predator diffused exactly at a time when centralized civilian control was the strongest—(1) cooperation had become the norm after Secretary of Defense Robert McNamara's tenure in the 1960s, (2) the 1986 Goldwater-Nichols Act mandated" jointness" and the services used it as a shield against civilian involvement (i.e., tradeoffs are made on the friendliest possible terms), and (3) UAV funding was centralized under DARO.

decades after cancelling the Lightning Bug program in 1975. It watched, unconcerned and uninterested, as the Army poured a billion dollars into a futile attempt to develop the Aquila during the 1980s. When the Predator emerged during the 1990s, Ron Fogleman, the Air Force chief of staff, recognized that technological advances had not only made the technology viable, but had shifted relative advantage in its favor compared with sustaining alternatives. As noted in the historical narrative above, Fogleman declared, "We are now impressed by the convergence of technological advances in computers, flight controls, lightweight materials, advanced electric motors and communications packages that will make modern UAVs extremely effective."[761] Fogleman was also influenced to compete with the Army for control over the Predator after the drone, deployed in support of operations over the former Yugoslavia, demonstrated promise in combat, thereby boosting trialability and observability. "Predator took on a life of its own and I thought it best that airmen operated the system," Fogleman recalled.[762]

Third, is the pace of innovation binary? In other words, does it occur at one of two speeds: fast or slow? Or, does it tend to occur commensurate with the rate at which relative advantage evolves?

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[761] Sue Baker, "AF Creates UAV Office," *Air Force News Service*, unspecified date in 1995, available at www.fas.org/irp/news/1995/n19951114_1260.html. Note: advancements in satellite connectivity occurred in the early 2000s, after Fogleman's tenure as Air Force chief.

[762] Thomas Ehrhard, *Air Force UAVs: The Secret History (*Arlington, VA: Mitchell Institute Press, 2010), 50. "[Fogleman] believed UAVs were a part of his service's future, not the Army's. Thus, an odd but useful design gained a patron" [Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 600]. "Fogleman bristled at the thought of the Army flying a system with performance higher than that of Hunter. 'If the Army took Predator, they would just screw it up and the program would go down the tubes; if anyone was going to make it work, we were,' said Fogleman [Ehrhard, *Air Force UAVs*, 50-51].

To date, unmanned aircraft have followed what Clayton Christensen's research suggests is a common pattern of adoption for disruptive innovations: gaining a foothold performing secondary roles and then graduating to core missions commensurate with the rate at which their relative advantage evolves.[763] Foundering for nearly a century, unmanned aircraft benefited from a confluence of technological advances in the 1990s. Subsequently, they have become more competitive over time. Although the Predator started life as a reconnaissance drone, the addition of an MTS ball, laser-designator, and Hellfire missiles allowed it to expand its mission repertoire and encroach upon high-end airpower missions such as close air support and strike, previously the exclusive purview of manned fighters and bombers. This march "up market" did not end with the Predator's evolution from a reconnaissance to multi-role aircraft. The drone spawned the MQ-9 Reaper, often referred to as "Predator on steroids," which delivers substantially improved performance over the Predator.[764] The Reaper has a 950-horsepower turboprop engine, far more powerful than the Predator's 105-horsepower piston engine. The Reaper flies three times faster than the Predator and twice as high. Additionally, the MQ-9 carries fifteen times the external payload as the MQ-1.[765]

Although technological advances have yet to make unmanned aircraft the equivalent of a fourth or fifth-generation fighter, the performance gap has narrowed. Consider the capability of the MQ-9 versus that of the F-16. The MQ-9 carries 3,000 pounds of external ordnance, including 500-pound laser guided bombs, essentially matching the carrying capacity of an F-16.

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[763] Indeed, unmanned aircraft have mimicked the same pattern of adoption as manned aircraft and helicopters, both of which gained a foothold performing reconnaissance and other niche support roles (e.g., medical evacuation in the case of helicopters) and then graduated to perform core combat missions (e.g., attack). Uniquely, missiles went from foundering in an emergent stage for a nearly a millennium to competing directly with manned nuclear bombers (see ICBM case study, Chapter 3).

[764] John A. Tirpak, "Rise of the Reaper," *Air Force Magazine*, February 2008, available at http://www.airforce-magazine.com/MagazineArchive/Pages/2008/February%202008/0208reaper.aspx.

[765] The Predator carries two 105-pound Hellfire missiles.

The MQ-9, however, cannot carry the variety of weapons the F-16 carries, nor can it match the speed or altitude of the F-16.[766] Nevertheless, the attraction of unmanned aircraft, a new class of weapon, does not rest solely in their ability to match or surpass the traditionally valued capabilities of manned aircraft. For example, unmanned aircraft provide the ability to project power while minimizing vulnerability, an attractive quality.

In summary, UAV innovation has not occurred at a single speed, but accelerated commensurate with the evolution of relative advantage offered by the platform. As the new class of weapon passed into general use, it attracted more investment, which, in turn, helped accelerate technological advances, improving the weapon's performance and relative advantage.

Fourth, did civilians or military leaders drive weapon system innovation, or were both civilians and uniformed leaders influential?

This chapter chronicles how three leaders—General Ron Fogleman, General John Jumper, and Defense Secretary Robert Gates—were instrumental in the adoption of the Predator, the breakout aircraft that kicked off what appears to be an on-going unmanned revolution in airpower.[767] These leaders helped overcome institutional resistance within the Air Force, allowing unmanned aircraft to break free from a seemingly perpetual state of emergence and into the growth phase of their technological life cycle. Recognizing how changes in

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[766] The Reaper, which currently carries the Hellfire missile and laser-guided bombs, will soon be fitted to drop Small Diameter Bombs (SDBs) and Joint Direct Attack Munitions (JDAMs) via GPS guidance.
[767] Uniformed leaders within the Army also championed for the adoption of UAVs.

perceived attributes of the technology meant unmanned aircraft had arrived at an inflection point, Fogleman incubated the Predator program. After Fogleman retired, Jumper carried the UAV torch, shepherding the technology through its early growth phase. Finally, Gates helped accelerate UAV growth and started to enforce tradeoffs, cannibalizing manned aircraft to fund an expanded unmanned fleet. In conclusion, both military and civilian leaders helped drive UAV innovation.

CHAPTER 6

CONCLUSION

"This is a seminal time, I think, in the history of the Air Force … I don't think there's any doubt that we are also transitioning to an unmanned aircraft type of situation [in air warfare] which would be a wrenching experience, very frankly, for the United States Air Force."[768]

— *Senator John McCain*

The last chapter of this study summarizes findings, speculates about the future of airpower (specifically the mix of manned and unmanned aircraft in the U.S. Air Force and U.S. Army inventories), and highlights policy implications. It ends by suggesting future directions for research.

SUMMARY OF FINDINGS

This dissertation began by noting that the rapid rise of unmanned aircraft over the last decade gives the misleading impression that the technology suddenly blossomed out of nowhere. In reality, unmanned aircraft technology dates back to the infancy of aviation itself. Indeed, unmanned aerial vehicles (UAVs) foundered as mere footnotes in aviation history for nearly a century before abruptly experiencing exponential growth, with no end in sight. The observation raised two questions: why now, and what can we anticipate for the future?

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[768] Senate, Committee on Armed Services, *Hearing to Receive Testimony on the Department of the Air Force in Review of the Defense Authorization Request for Fiscal year 2010 and the Future Years Defense Program*, 21 May 2009, 4, http://armed-services.senate.gov/Transcripts/2009/05%20May/09-35%20-%205-21-09.pdf.

To help answer those questions, this investigation first surveyed existing literature on military innovation and found the field dominated by three political science theories, those put forth by Barry Posen, Stephen Rosen, and Owen Coté.[769] Posen, Rosen, and Coté's theses, however, address doctrinal innovation, a related but different line of research than the focus of this study: weapon system innovation. Doctrinal innovation research analyzes when and why military organizations make major changes in the way they fight, which may or may not include new weapons. Weapon system innovation, on the other hand, always does. Nevertheless, the investigation argued that doctrinal innovation research is relevant, although it insufficiently explains weapon system innovation.[770]

The study alleged that the three political science theories are incomplete because they overlook research in other innovation fields of study and as a result miss the most influential underlying source of innovation: the perceived attributes of innovations.[771] Based on a central finding of Diffusion of Innovation (DOI) research, the dissertation hypothesized that four perceived attributes—relative advantage, compatibility, trialability, and observability—of which relative advantage is the most important, account for the majority of the variance in whether

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[769] Their theories respectively ascribe independent causal significance to three sets of relationships: civil-military, intraservice, and interservice [Owen Reid Coté, Jr. "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Massachusetts Institute of Technology Dissertation, 1996, 6].

[770] The dissertation made the argument that Posen, Rose, and Coté's theories apply to weapon system innovation based on the following reasons: first, definitional ambiguity and mixed messages in their research left open the possibility that the adoption of new combat arms could be considered a sub-category of the doctrinal-innovation field of study. In other words, the adoption of new combat arms can be viewed or defined as doctrinal innovation stimulated by changes or opportunities in technology. Second, two scholars, Thomas Ehrhard and Sean Frisbee, found evidence to suggest factors that shape doctrinal innovation also influence weapon system innovation.

[771] It is important to emphasize that the study did not discard insights from existing military innovation literature; it acknowledged that the two factors Posen, Rosen, and Coté identify as drivers of innovation—changes in the nation's security situation and interservice competition—can influence the adoption of new weapons.

and how quickly new weapons are adopted.[772] The investigation, however, noted a shortcoming in DOI research: it does not describe how the alluring attributes of new technologies overcome the inertial behavior of organizations. Fortunately, business innovation research informs this deficit.

Clayton Christensen, a Harvard Business School professor, identifies two patterns in commercial innovation that this study maintained are also exhibited in weapon system innovation; the patterns inform how the relative advantage and attractiveness of new and existing classes of weapons can change over time. First, Christensen observes that commercial incumbents tend to pursue improvements to existing products which leads to ripe conditions for disruptive innovations. In a military context, the dominant subcultures within each service, similar to commercial incumbents, perennially pursue ever-more-perfected versions of their favored weapon system. They do so because sustaining innovations, early in their life cycle, characteristically offer greater relative advantages than disruptive innovations.[773] Although sustaining innovations deliver more capable weapons, they also tend to produce ever-more complex and costly versions, making the weapon less cost efficient. At some point, sustaining innovations paradoxically deliver new generations with diminishing relative advantages.

Second, Christensen suggests that disruptive innovations tend to follow a common pattern of adoption; they typically underperform, at least initially, when judged against existing

[772] The dissertation grouped the three factors that underlie and influence weapon system innovation—changes in a state's security situation, interservice competition, and the perceived attributes of an innovation—under a concept called "willingness to cannibalize" (see Figure 2, Chapter 1).
[773] New classes of weapons tend to have higher uncertainty surrounding any payoff, lower perceived benefits (at least from an incumbent's perspective), and higher organizational costs, which translates, all else being equal, into lower expected values versus sustaining alternatives (see Chapter 2).

products, but offer benefits that appeal to those not served well by sustaining innovations.[774] Disruptive innovations tend to provide "good enough" capability for low-end users and/or offer a whole new population access to a capability it previously did not enjoy. As a result, the disruptors often take root serving secondary, fringe, or niche markets and then blossom with time to encroach on mainstream markets.[775] The equivalent in a military context is for new classes of weapons to first fulfill peripheral roles and then graduate to core missions, progressively displacing existing weapon systems commensurate with the rate at which their relative advantage evolves.

Taken together, Rogers and Christensen posit a tension between the allure of new technologies and the inertia of practice inherent in most organizations. In general, "willingness to cannibalize" requires, to use a business expression, a significant change in either the market or market conditions. In a military context, the three explanatory factors identified in Figure 2, Chapter 1, acting in isolation or together, can tip the balance in favor of new classes of weapons.[776] For example, the threat of Nazi scientists developing atomic weapons proved a great stimulus to the Manhattan Project. Similarly, breakthroughs in enabling technologies, such as the turbine engine for helicopters or thermonuclear warheads for ICBMS, can amplify their utility and relative advantage. Visionary leaders, sensing and interpreting these evolving factors, act upon their instincts and move organizations to change.

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[774] Clayton M. Christensen, *Innovator's Dilemma*, First Collins Business Essentials ed. (New York, NY: HarperCollins, 2006), xv.

[775] Ibid.

[776] Changes in a state's security situation and the emergence of interservice competition can be thought of as changes in market conditions while changes in perceived attributes of innovations are analogous to changes in the market.

While Posen, Rosen, and Coté's insights often apply to the three cases examined in this study, gaps appear in their explanations. The combination of Rogers and Christensen fills some of those gaps when it comes to the adoption of the intercontinental ballistic missile (ICBM), the helicopter, and the UAV. [777]

The Perceived Attributes of Innovations

In all three cases, the perceived attributes of each weapon weighed heavily in its development and adoption, more so than changes in the nation's security situation and interservice competition. The ICBM benefited from an abrupt shift in relative advantage from the invention of the thermonuclear bomb.[778] Thermonuclear warheads not only made the ICBM much more feasible, they also made the nuclear missile immensely more attractive.[779] The technological advance helped sway Trevor Gardner, Bernard Schriever, and most importantly Thomas White, who made the pivotal decision in May 1954 to elevate the ICBM to the top of the Air Force's R&D priority list and then steadfastly shepherded the disruptive weapon's adoption despite protests from the bomber constituency.

[777] The investigations focused on four differences in the explanations offered by existing theories and the proposed model. First and most critical, did changes in a state's security situation and interservice competition, the two factors identified in doctrinal innovation literature as drivers of innovation, sufficiently explain when and why the U.S. military adopted the ICBM, the helicopter, and the UAV? Or, per this study's central hypothesis, did the perceived attributes of innovations also weigh heavily in leaders' decisions? Second, was interservice competition, as Coté alleges, overwhelmingly a function of "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services"? Or, did the perceived attributes of innovations also influence competitive and cooperative patterns of service behavior? Third, was the pace of innovation binary? In other words, did it occur at one of two speeds: fast or slow? Or, did the adoption of innovations occur commensurate with the rate at which relative advantage evolves? Fourth, did civilians or military leaders drive weapon system innovation, or were both civilians and uniformed leaders influential?

[778] Other technological advances, such as improvements made in missile navigation, ablative shielding, etc., also increased the disruptive weapon system's relative advantage, making its adoption much more attractive (see Chapter 3).

[779] The H-bomb provided a high-yield, low-weight, reliable, and small warhead that could be married to a ballistic missile.

White acted because he believed "the combat potentialities of missiles offered certain advantages in comparison with manned systems."[780] The growing missile threat from the Soviet Union may have influenced him, but evidence indicates the concern exerted little more than background influence.[781] In 1957, the Soviet launch of Sputnik generated intense public and congressional interest in speeding the development of missile development. The event, however, occurred more than three years after White's pivotal decision and well after the Air Force had embarked on a crash ICBM development program.

The Air Force's adoption of the ICBM does not appear to have been a product of interservice competition. The Army and Navy belatedly entered into competition over missiles. Moreover, they had to be spurred into competition by the actions of Secretary of Defense Charles Erwin Wilson, who coaxed them into a partnership to build the Jupiter, an Intermediate Range Ballistic Missile (IRBM). The Air Force responded with an IRBM design of its own, the Thor. The competition over the IRBM diverted resources from the Atlas program and may have slowed the fielding of the nation's first ICBM.

In the end, the Air Force and the Navy adopted strategic missiles while the Army did not. The outcome speaks to the compatibility of strategic missiles with each service. The ICBM found a natural home with the Air Force, a service that was steeped in strategic nuclear attack, albeit with a different delivery system, the manned bomber. The Army, which viewed the strategic nuclear attack mission as largely incompatible with land operations, competed to develop and adopt an Intermediate Range Ballistic Missile (IRBM) principally to retain a share of

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[780] Thomas D. White, "Air and Space are Indivisible," *Air Force Magazine*, March 1958, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1958/March%201958/0358indivisible.aspx].
[781] Schriever wrote, "We were *energized by technology and not by intelligence data*" (emphasis added) [Bernard Schriever, "The Air Force's Ballistic Missile Program," *Air Force Magazine*, April 1958, available at http://www.airforce-magazine.com/MagazineArchive/Pages/1958/April%201958/0458ballistic.aspx].

the increasingly nuclear-bomb-reliant Eisenhower budget. But Army leaders were far from troubled over losing the competition to the Air Force. The Navy had to be cajoled into a partnership with the Army to develop the Jupiter, a rocket that relied on volatile liquid-fuel technology that was incompatible with naval operations. Accordingly, it pulled out of the Jupiter project as soon as the technology became possible to develop the Polaris, a solid-fueled submarine-launched ballistic missile (SLBM).

Compatibility appears to also explain much of the reason why the Air Force lacked interest in the helicopter and why the Army embraced it. For the Air Force, particularly from the perspective of the "bomber mafia," the service's dominant subculture for nearly thirty years, rotary-wing aviation was incompatible with the service's past experiences and primary mission: strategic bombing. Manned bombers had brought victory in World War II; now, they could fly higher, faster, and farther to deliver a destructive power that far exceeded any in history.[782] Embracing low-and-slow helicopters would have kept Air Force pilots close to the battlefield and in support of the Army, the last place they wanted to be.[783]

Accordingly, bomber generals shunned the helicopter and funneled the vast majority of Air Force research-and-development (R&D) funds into programs to build bigger, faster, and higher-flying nuclear bombers. As a result, the Army found itself in a difficult situation. With the split between the Army and Air Force in 1947, the Army was dependent on the Air Force for its air support, but the Air Force considered the Army a secondary customer and possessed scant interest in developing aircraft to support the senior service. The helicopter offered the

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[782] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 133.

[783] The Air Force adopted relatively few helicopters. It principally used the helicopters it did buy for search and rescue, a mission supporting its fleet of manned fixed-wing aircraft.

Army a “good enough” capability and an opportunity to rebuild its organic airpower capability. In some respects, particularly as technology advanced, the helicopter provided a better match than fixed-wing aviation for the Army’s airpower requirements. Besides, bureaucratic restrictions prevented the Army from adopting manned fixed-wing aircraft. So the choice was really between continuing to rely on the Air Force for air support, an option Army leaders were dissatisfied with, or adopting the new class of weapon. Since helicopter technology blurred previously defined roles-and-missions boundaries, the Army used rotary-wing aircraft to nibble away at geographic, weight, and functional restrictions that had prevented it from acquiring its own airpower.

The helicopter cut its teeth during the Korean War, an opportune trial-by-fire that showcased its promise and led to improved trialability and observability. Nevertheless, the opportunity to experiment with the helicopter on a limited basis highlighted performance limitations of early rotary-wing aircraft. The development of the turbine engine, a technological breakthrough that vastly improved performance, allowed helicopters to expand beyond performing niche roles such as medical evacuation, reconnaissance, and VIP transport.

The Army’s interest in rotary-wing aircraft cannot be attributed to interservice competition. Far from competing with the Army to adopt the helicopter, the Air Force, as mentioned earlier, shunned the helicopter and fought for decades to impede the Army’s adoption of the weapon.

Changes in the nation’s security situation, notably the wars in Korea and Vietnam, accelerated the U.S. Army’s adoption of the helicopter, but attributing the service’s adoption of the weapon to the advent of nuclear weapons and ballistic missiles, as Stephen Rosen does,

seems a stretch.[784] The Army had acquired thousands of helicopters before concerns over mobility on a nuclear battlefield surfaced. The service may have counted many more helicopters in its inventory if not for Air Force obstruction of its rotary-wing development efforts.

The perceived attributes of drones also appear to have weighed heavily in leaders' decisions to adopt unmanned aircraft. Prior to the Predator, the breakout UAV that launched the apparent on-going revolution in airpower, technological immaturity meant unmanned aircraft offered lower relative advantage than the manned alternatives. Of the approximately two dozen UAV programs the U.S. military had pursued, none offered a worthwhile return on investment. The Predator succeeded when previous UAV programs had failed because it benefited from the confluence of critical enabling technologies that occurred in the early 1990s. The Predator was the first UAV to capitalize on light-weight, low-cost GPS receivers, which eliminated a major driver of mission failure among earlier unmanned systems—inaccurate navigation. Satellite technology also allowed the Predator to cast off line-of-sight range limitations. Additionally, the Predator did not have to employ complex launch and recovery procedures because advancements in computer technology enabled "real time" control, thereby allowing it to operate from conventional runways. Furthermore, the Predator benefited immensely from the digital revolution; advances in computer and satellite technology allowed the UAV to push its real-time video feeds anywhere around the planet over the military's secure internet, providing unparalleled portability and distribution of intelligence.

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[784] Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 72. Note: tactical nuclear weapons were developed and deployed in the late 1950s and early 1960s.

The Predator also benefited from a string of early successes that boosted two important perceived attributes: trialability and observability. First, General Atomics delivered on its promise to fly a prototype within six months of being awarded the contract. This accomplishment was refreshing, especially when one considers the Army's experience with the Aquila. The Predator also came in below budget and was cheap. Third, the prototype showed immediate promise after canvassing reconnaissance targets at ROVING SANDS. Exercise results encouraged leaders to send the drone into combat for a trial by fire. Fourth, although the Predator experienced some operational hiccups, it demonstrated utility flying missions over the former Yugoslavia and later Iraq and Afghanistan.

These wars provided venues for the Predator to demonstrate its effectiveness and fueled growth, similar to how the Korean and Vietnam Wars did for the helicopter. But changes in the state's security situation, whether due to wars or otherwise, do not explain the Army's long-standing and the Air Force's episodic interest in unmanned aircraft.

Over the nearly century-long history of the UAV, interservice competition rarely affected Air Force and Army's UAV development decisions and does not appear to be the primary driver of UAV innovation.[785] Furthermore, although interservice competition played a significant role in the adoption of the Predator, it did not occur for the reason given by Owen Coté: "civilian management styles, particularly with regard to the process for allocating budget shares to the individual services."[786] UAVs experienced exponential growth precisely when his model suggests interservice competition, and hence innovation should have been dead. First, Coté

785 Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 571. See also p. 599.
786 Ibid.

claims interservice competition essentially ceased with the appointment of General Earle Wheeler as chairman of the joint chiefs in 1964. Wheeler institutionalized a practice of muting interservice disagreement in order to thwart Secretary of Defense Robert McNamara's centralized management style.[787] Second, Congress's push for "jointness" through the enactment of the 1986 Goldwater-Nichols Act created strong systemic disincentives for interservice competition.[788] In fact, the Joint Requirements Oversight Council (JROC), a body created by the Goldwater-Nichols Act, swiftly mediated the interservice competition over the Predator, awarding ownership to the Air Force. Third, the Predator emerged at a time when Congress centralized control and management of the reconnaissance budget under the Defense Airborne Reconnaissance Office (DARO). Using Coté's theory, one would expect the services to react to this "grand experiment in civilian intervention and centralized control" in the same way Coté says they did when Secretary of Defense Robert McNamara introduced centralized planning, programming, and budgeting procedures to strengthen civilian management control back in 1964—by banding together.[789]

Rather than being a function of civilian management styles, the driving factor behind the emergence of interservice competition over the Predator was largely technological. First, unmanned aircraft technology lowered barriers to entry associated with the Army regaining a foothold in fixed-wing aviation. Second, the Predator benefited from the confluence of critical supporting technologies in the 1990s that tipped relative advantage in its favor compared with manned alternatives. This shift in relative advantage, reinforced by improved trialability and

[787] Ibid, 18 and 351.
[788] Harvey M. Sapolsky, "Interservice Competition: The Solution, Not the Problem," *Joint Forces Quarterly*, No. 15, Spring 1997, 51.
[789] Thomas P. Ehrhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation," Johns Hopkins University Dissertation, June 2000, 496.

observability after the Predator's successful deployment to the Balkans, enticed the services to compete over the weapon. In other words, the perceived attributes of the Predator played a significant role in whether and when interservice competition emerged. The Air Force had sat on the UAV sidelines for two decades after the Vietnam War and watched, unconcerned and uninterested, as the Army poured a billion dollars into a futile attempt to develop the Aquila during the 1980s. After the Predator demonstrated utility, Ron Fogleman declared, "We are now impressed by the convergence of technological advances in computers, flight controls, lightweight materials, advanced electric motors and communications packages that will make modern UAVs extremely effective."[790]

The perceived attributes of the ICBM and the helicopter also influenced competitive and cooperative patterns of service behavior. In order for interservice competition to emerge, at least two services must perceive that a disruptive innovation offers an attractive alternative to the status quo. None of the services embraced the missile prior to the development of the thermonuclear bomb because, to paraphrase Trevor Gardner, it was not worth the game. Competition emerged only after the perceived attributes of nuclear missiles evolved, making the weapon more attractive. Even then, the Navy waited until a solid-fueled missile, a weapon more compatible with naval operations, became viable before it wholeheartedly entered into competition.

In the case of the helicopter, the Air Force elected not to compete with the Army over the weapon because the junior service perceived that the relative advantage offered by its fixed-wing force dwarfed that offered by rotary-wing aviation. In the only mission area where

[790] Sue Baker, "AF Creates UAV Office," *Air Force News Service*, unspecified date in 1995, available at www.fas.org/irp/news/1995/n19951114_1260.html.

the two services competed—the competition between the Cheyenne and the A-10 to provide close air support—the Air Force met the challenge by offering a fixed-wing alternative.

Christensen's Two Patterns

In addition to revealing that the perceived attributes of each weapon (1) weighed heavily on development and adoption decisions and (2) influenced competitive and cooperative patterns of service behavior, the three cases also offer evidence that the two patterns Clayton Christensen identified in commercial innovation are exhibited in weapon system innovation. First, in line with Christensen's model that observes how incumbents perennially pursue sustaining innovations, this investigation chronicled the Air Force's history of pursuing ever-more perfected versions of the manned bomber and fighter.

Since the service achieved independence in 1947, it has been ruled by two dominant subcultures: bomber and fighter pilots.[791] For the first three decades, the bomber-pilot-dominated Air Force leadership, with the exception of Thomas White who fought vigorously against entrenched interests to shepherd the ICBM into the service's inventory, prioritized the bomber, developing high-end weapons designed to deliver nuclear payloads. Not surprisingly, fighter pilots, when they assumed power, demanded more and better fighters, culminating most recently in the F-22, a fifth-generation fighter. These sustaining innovations delivered more capable aircraft, but also more complex and costly weapons. Figures 4 and 5 (see Chapter

[791] The lineage of service chiefs reflects this shift in power. Bomber pilots dominated the top position of the service until 1982 when Charles Gabriel, a fighter pilot, took over. After Gabriel became chief, ten fighter pilots in a row filled the position. (Note: the figure includes two acting chiefs: John J. Loh and Ralph E. Eberhart.) The string was broken only after Robert Gates fired T. Michael Moseley and installed Norton Schwatz, a C-130 pilot, to command the service because he wanted to encourage change.

2), respectively, document the exponentially escalating unit costs of fighters and bombers since early military aircraft took to the skies.

Whether (or at what point) cycles of sustaining innovation to manned fighters and bombers have paradoxically delivered weapons with lower relative advantage is subject to subjective judgment. Certainly, they have produced technological marvels, but the question is whether the difference in capability costs more than it is worth. For example, the XB-70 was Curtis LeMay's dream plane, and he thought it was essential to the security of our nation. Nevertheless, in the judgment of two administrations and many in Congress, the staggering cost of the XB-70 made the program unnecessary and economically unjustifiable, particularly given the ICBM alternative.[792]

Has today's lineage of fifth-generation manned fighters similarly reached a point of diminishing relative advantage? Secretary of Defense Robert Gates suggested as much when he curtailed production of the F-22, calling the plane a "niche, silver-bullet solution required for a limited number of scenarios."[793] Moreover, the ballooning costs of the F-35 Joint Strike Fighter (JSF), the latest fifth-generation fighter in development, suggest fighter innovation will continue to paradoxically deliver aircraft with diminishing relative advantage.

Indeed, the JSF program offers an instructive example of how cost and complexity feed off each other in a vicious, reinforcing cycle (see Chapter 2). The average price of each JSF has more than doubled from when the contract was signed in 2001; including development costs,

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[792] John F. Kennedy, "99 - Special Message to the Congress on the Defense Budget" (speech, Congress, Washington, DC), 28 March 1961, available at http://www.presidency.ucsb.edu/ws/index.php?pid=8554#axzz1s79eBmzK. Big bombers have been produced since the XB-70, but their numbers have dwindled almost 90% from their post-WWII peak (see Figure 6, Chapter 2).

[793] Rebecca Grant, "The Evolution of Airpower Under Gates," *Air Force Magazine*, February 2011, 57.

each plane now costs more than $300 million.[794] Since 2007, costs have risen 26%, and delays have slipped planned aircraft delivery more than five years.[795] Frustrated, Robert Gates fired the JSF program manager and directed restructuring of the program, the sixth one in the plane's history.[796] After more than nine years in development and four in production, the JSF program has yet to achieve a stable aircraft design or demonstrate that the weapon system is reliable.[797] Senator John McCain called the JSF a "train wreck" and accused Lockheed Martin, the jet's manufacturer, of doing "an abysmal job."[798]

The Economist, one of many news organizations to arrive at the same conclusion, predicts more troubles: "If orders start to tumble, the F-35 could go into a death spiral [due to negative economies of scale]. The fewer planes governments order, the more each one will cost and the less attractive the F-35 will be."[799] The planned JSF purchase has already been slashed by nearly one-third, yet mounting pressure exists for more cuts.[800] Even F-35 champions concede that the aircraft will probably be the last manned strike fighter that the West will build.[801]

Two of the three cases investigated in this study also reveal evidence supporting the assertion that many disruptive innovations follow a common path to adoption: from peripheral

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794 GAO Report to Congressional Committees (GAO-08-467SP), "Defense Acquisitions: Assessments of Selected Weapon Programs", March 2008, 7. See also Craig Whitlock, "Defense Secretary Gates Fires General in Charge of Joint Strike Fighter Program," *Washington Post*, 2 February 2010, available at http://www.washingtonpost.com/wp-dyn/content/article/2010/02/01/AR2010020103712.html.
795 "The Defence Industry: The Last Manned Fighter," *Economist*, 16-22 July 2011, 68.
796 Ibid.
797 Ibid.
798 Ibid.
799 Ibid.
800 Jen DiMascio and Michael Bruno, "Senate Appropriators Slice $700M Off JSF," *Aviation Week*, 13 September 2011, available at http://www.aviationweek.com. In the mid-1990s, Ronald Fogleman predicted that later blocks of the Lockheed-manufactured JSF would be unmanned.
801 Bryant Jordan, "On AF B-Day Will Pilots Be 'Obsolete?'" Military.com, 18 September 2010, available at http://www.military.com/news/article/on-af-bday-will-pilots-be-obsolete.html. See also "The Defence Industry: The Last Manned Fighter," *Economist*, 16-22 July 2011, 68.

to mainstream.[802] The helicopter gained a foothold performing peripheral roles (e.g., medevac, search and rescue, reconnaissance, etc.) and then blossomed over time to assume core mobility and firepower functions within the Army. The weapon's march "up market" did not occur at a single speed, but accelerated commensurate with the evolution of relative advantage offered by new generations of the technology. To date, the UAV has followed a similar path, taking root performing persistent surveillance, a monotonous and dull niche mission, and increasingly graduating to core combat missions, such as close air support and strike.

While the Predator vastly underperforms existing manned aircraft, it spawned UAVs such as the MQ-9 Reaper that are beginning to narrow the capability gap. Although not much is known publically about the RQ-170 Sentinel, the latest, highly-classified unmanned aircraft to emerge from the shadows of military secrecy, the stealthy jet seems to offer greatly improved capabilities in terms of speed and survivability.[803] It serves as a harbinger of rapidly advancing technology and an accelerating pace of adoption of unmanned aircraft as the weapon marches "up market" into more applications.

With the acquisition of the MQ-X, an unmanned aircraft slated to become operational early next decade, the Air Force will gain a quantum jump in capability. Lieutenant General David Deptula, the former deputy chief of staff for intelligence, surveillance and reconnaissance, thinks the leap in capability offered by the MQ-X will be as large as the advance

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[802] The ICBM was the exception. Intriguingly, the helicopter and the UAV's paths to adoption have been remarkably similar to that followed by manned aircraft.
[803] The RQ-170 employs a "flying wing" design, making it look like a mini B-2 stealth bomber. The RQ-170 loitered undetected in Pakistani airspace for months prior to the raid that killed Osama bin Laden [Mark Thompson, "RQ-170 Sentinel Aircraft," *Time*, 29 June 2011, available at http://www.time.com/time/specials/packages/article/0,28804,2074830_2074827_2074845,00.html].

from biplanes to the jet age.[804] The general, a fighter pilot himself, declared, "The future of how you use these [MQ-Xs] is really unlimited."[805] A useful and novel design attribute of the MQ-X is its "modularity." The design calls for the aircraft to have the capability to be rapidly reconfigured, enabling the jet to fulfill any of a number of widely divergent missions.[806] According to Deptula, modularity will provide the UAV with a diverse set of capabilities "much, much different than anything we've seen before."[807] For example, modularity would enable to MQ-X to fly combat strike missions one day and then switch to become a cargo transporter the next.

THE FUTURE OF AIRPOWER

Air Force

The U.S. Air Force is investigating the use of UAVs in a multitude of missions, including expanded strike roles, air transport, air refueling, suppressing enemy air defenses, forward air

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[804] John A. Tirpak, "The RPA Boom," *Air Force Magazine*, August 2010, http://www.airforce-magazine.com/MagazineArchive/Pages/2010/August%202010/0810RPA.aspx.

[805] Nic Robertson, "How robot drones revolutionized the face of warfare," *CNN*, 26 July 2009, http://www.cnn.com/2009/WORLD/americas/07/23/wus.warfare.remote.uav/index.html. New prototypes are appearing at what seems like a frantic pace, and not just in the United States as Boeing recently unveiled its Phantom Ray, an aircraft it financed entirely out of company funds, which will test not only advanced ISR capabilities, but also suppression of enemy air defenses, electronic attack, and autonomous aerial refueling. "The possibilities are nearly endless," said Dennis Muilenburg, president and CEO of Boeing Defense, Space & Security [http://www.boeing.com/Features/2010/05/bds_feat_phantomRay_05_10_10.html]. BAE Systems also rolled out its new unmanned design, the Taranis, named after the Celtic god of thunder. "Capable of being operated by remote control from anywhere in the world via a satellite link, it can fly from one continent to another, carrying out surveillance or dropping bombs and firing missiles at ground targets," details *The Economist*. "But it is also capable of another trick: the ability to defend itself, like a jet fighter, if it is attacked by another drone or by a manned aircraft" ["Robo Raider: A new drone emerges with the ability to fight back," *Economist*, 15 July 2010, http://www.economist.com/node/16588695?story_id=16588695&fsrc=rss].

[806] Nic Robertson, "How robot drones revolutionized the face of warfare," *CNN*, 26 July 2009, http://www.cnn.com/2009/WORLD/americas/07/23/wus.warfare.remote.uav/index.html.

[807] Ibid.

control, combat search and rescue, and more.[808] As a result, UAVs are poised to become more numerous and play a prominent role in virtually every mission area. Nevertheless, the outcome of this apparent unmanned revolution in airpower is not determined or foregone.[809] While the prospects for an increasingly "unmanned" U.S. Air Force appear high based on the trajectory of unmanned growth, continued innovation very much depends on the actions of those in power. The cross-disciplinary model in this study predicts stiffening resistance as unmanned aircraft become more competitive in core missions, thus threatening fighter pilots, the dominant subculture within the service. As a result, "willingness to cannibalize" may subside.

The Air Force's response to the manned-to-unmanned shift has been typical of incumbents whose core operating models have been challenged by the emergence of disruptive innovations: dismiss, disparage, and then bargain (see Chapter 2).[810] General Kenneth Israel, the director of the Defense Airborne Reconnaissance Office (DARO) from 1993-1998, recalled how his advocacy of unmanned aircraft fell on deaf ears. His efforts to educate Air Force leaders on the potential value unmanned aircraft were, according to a Pulitzer-prize-winning article, "muddied by military officials who wanted money for manned aircraft."[811] Israel described his struggle against the establishment this way: "In a typical work year, I had about 250 meetings, and most of them were [negative] … It was a struggle every day to make

[808] Norton Schwartz, "Future of Unmanned Aircraft" (remarks at the graduation ceremony for the Unmanned Aircraft System MQ-1 Predator Course, Creech Air Force Base, Nevada, 25 September 2009), 4, available at http://www.af.mil/shared/media/document/AFD-091001-013.pdf.
[809] To emphasize, per this study's central hypothesis, the continued growth of unmanned aircraft depends on the evolution of its perceived attributes, especially relative advantage. The exponential trajectory of UAV growth may not be sustained if UAVs fail to deliver a relative advantage over manned alternatives. For example, the RQ-4, nicknamed the "Escalade of drones" by the *New York Times*, was supposed to replace the U-2, but the Air Force cancelled the Global Hawk program in favor of the U-2; Congress, however, wants to reinsert it into the budget.
[810] "Bargain" refers to how incumbents often insist that new weapons are best used in conjunction with existing ones.
[811] Thomas E. Ricks and Anne Marie Squeo, "Sticking to Its Guns," *Wall Street Journal*, 12 October 1999, available at http://www.pulitzer.org/archives/6361. "[General Israel's] office met continual resistance from Air Force officials who pushed for ever-more advanced manned fighters …" [Ibid].

people aware of what UAVs could do."[812] Noting the pilot-dominated Air Force hierarchy has traditionally been biased against UAVs, Israel observed, “Critics determined that the best way to slow down a bold and innovative idea was to load it down with cultural innuendoes and inaccurate comparisons between manned and unmanned aircraft.”[813]

Negative attitudes about unmanned technology and its perceived incompatibility with a warrior ethos colored budgeting decisions. The following disparaging comment made by a senior Air Force official when considering whether to continue funding the Lightning Bug, the service’s most promising drone program in the Vietnam era, typifies endemic cultural resistance to unmanned aircraft within the Air Force: “How can you be a tiger sitting behind a console?”[814] Although senior Air Force officers have learned from Secretary of Defense Gates’s firing of General Moseley not to be open obstructionists, rank-and-file fighter pilots remain more candid. Summing up the prevailing view among his peers, one F-15C pilot told *Smithsonian Air & Space*, “I’d shoot myself [rather than fly a UAV]” in an interview for an article entitled “The Last Gunslinger.”[815] The young officer bemoaned the looming retirement of his steed, the F-15C, the Air Force’s “only dedicated dogfighter” left in the service’s inventory.[816]

In 2010, General Roger Brady, the Air Force’s commander in Europe, delivered a “strong message” to supporters of unmanned aircraft right before he retired (i.e., when he no longer

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[812] Ibid.

[813] Ibid. Although Israel remarked how the pilot-dominated Air Force hierarchy has always been biased against UAVs, he added that there also were “pockets of support” [Ibid].

[814] Joe Pappalardo, “The Future for UAVs in the U.S. Air Force,” *Popular Mechanics*, 26 February 2010, available at http://www.popularmechanics.com/technology/aviation/military/4347306. General Clarence Irvine, a bomber absolutist, made a very similar statement about the ICBM. Lambasting General Thomas White’s decision to move the ICBM to the top of the Air Force’s priority list, Irvine said, “I don’t know how to show your teeth with a missile” [Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 84].

[815] Michael Behar, “The Last Gunslinger,” *Smithsonian Air & Space Magazine*, 01 July 2010, available at http://www.airspacemag.com/military-aviation/The-Last-Gunslinger.html?c=y&page=4.

[816] Ibid.

had anything to lose professionally from speaking freely against Gates's transformative airpower agenda).[817] In what news organizations described as a "no-holds-barred" speech to more than 500 military leaders, engineers, scholars, and UAS manufacturers, Brady's message to the Air Force was simple: "Don't rely on UAVs!"[818] Brady declared, "In this debate, the burden of proof, in my opinion, is on the proponents of UAS [unmanned aircraft systems]. We know the advantages and disadvantages of manned aircraft. Technology must deliver, not merely promise to deliver, the same level of competence in UAS that we have learned to place in manned aircraft."[819] He implored the Air Force leadership to continue the service's policy of insisting its most-demanding missions should drive its force-structure decisions. "In these scenarios, a most-of-the-time solution will not be acceptable. What we must not do is allow fascination with technology to lure us away from [our historical focus]."[820]

Brady's comments could have been uttered by J. K. Herr, the Army's last Chief of Cavalry, who argued in 1939, "We must not be led to our own detriment to assume that the untried machine can displace the proved and tried horse" (see Chapter 2).[821] Brady's remarks also echo Curtis LeMay's 1956 testimony to Congress when he advocated for prioritizing the nuclear bomber over the ICBM: "*We believe that in the future the situation will remain the*

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[817] Scott Fontaine, "USAFE Chief: Don't Rely on UAVs," *Air Force Times*, 30 July 2010, available at http://www.airforcetimes.com/news/2010/07/airforce_UAVs_073010.
[818] Ibid.
[819] Ibid.
[820] Ibid.
[821] General Brady's remarks are also similar to the Navy establishment's view about the adoption of aircraft carriers. In 1920, the Navy General Board declared, "It would be the height of unwisdom for any nation possessing sea power to pin its faith and change its practice upon mere theories as to the future development of new and untried weapons" [Lee P. Warren, "The Battleship Still Supreme: Why Neither Aircraft Nor Submarine Has Yet Replaced the Capital Ship in Its Master of the Sea" in *The World's Work: A History of Our Time* Vol. XLI (November 1920 to April 1921), Eds. Walter Hines Page and Arthur W. Page (Garden City, New York: Doubleday, Page & Company, 1920-1921), 556].

same as it has in the past …" (emphasis added).[822] Like Brady, General Thomas Power, LeMay's protégé, insisted that the Air Force should remain wedded to technology that was in line with the service's historical technological focus: "Regardless of the missile program, it is the opinion of this headquarters that the continued advance in the art of manned flight to high altitudes and long ranges should be at all times a priority objective of the Air Force's development program."[823]

Where the Air Force chooses to spend its money illustrates its priorities. Even with Gates pushing for the expansion of the unmanned fleet, the Air Force still spends a pittance on unmanned aircraft compared to manned aircraft. In fiscal year 2009, the Air Force spent eight times as much to procure manned fighters and bombers than it did for additional Predators and Reapers. The Air Force plans to spend nearly $1 trillion to acquire and operate 1,763 Joint Strike Fighters.[824] By far, the JSF is the Pentagon's most expensive program. Notably, even after Gates ended F-22 production, the Raptor continues to rank sixth among the Pentagon's most expensive weapons programs due to its high operating costs and scheduled upgrades. In

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822 George A. Reed, "U.S. Defense Policy, U.S. Air Force Doctrine and Strategic Nuclear Weapon Systems, 1958-1964: The Case of the Minuteman ICBM," Duke University Dissertation, 1986, 20. Interestingly, a 1950 House Armed Service Committee Report observed, "All advocates of every theory of American security turn back to the experiences of World War II for historical examples— for illustrations—to prove the soundness of their own arguments." LeMay was still reaching back to his World War II experience more than a decade later.

823 Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1967*, Vol. I (Maxwell AFB, AL: Air University Press, 1989), 507.

824 Peter W. Singer, "U-Turn," *Armed Forces Journal*, April 2011, available at http://www.armedforcesjournal.com/2011/04/5787503. See also John A. Tirpak, "Washington Watch," *Air Force Magazine*, July 2011, available at http://www.airforce-magazine.com/MagazineArchive/Pages/2011/July%202011/0711watch.aspx. Together, the U.S. Air Force, Navy, and Marines plan to acquire 2,443 JSF aircraft. The total program acquisition cost, assuming no additional cost overruns (which some would say is a farcical assumption) equals $273.3 billion. The GAO estimates it will cost roughly another $1 trillion over the lifetime of those jets to pay for operations and maintenance costs. If research and development costs are included, unit costs exceed $300 million. Originally, the U.S. Air Force, Navy, and Marines were to buy upwards of 3,000 aircraft, but rising unit costs forced a substantial reduction in the planned purchase. More cuts are expected, which will further increase unit costs [Colin Clark, "Pentagon Reportedly Mulls Large JSF Cut," 19 September 2011, available at http://defense.aol.com/2011/09/19/pentagon-reportedly-mulls-huge-jsf-cut]. The JSF contract was awarded in 2001, and operational aircraft are not expected to be delivered until 2016.

contrast, unmanned aircraft are nowhere to be found on a list of the Pentagon's top 25 most expensive programs, a list which contains 10 manned aircraft.[825]

Even the Air Force's accounting system betrays its bias towards manned aircraft. Air Force leaders express its force posture based on "fighter wing equivalents."[826] Furthermore, the service's budget documents classify manned fighters and bombers as "combat aircraft" while it groups the MQ-1 and MQ-9 under a miscellaneous category called "other aircraft."[827] This goes back to the Air Force's insistence that unmanned aircraft are ancillary; including unmanned aircraft in the "other" category reinforces the belief that they serve other-than-core functions and that unmanned aircraft won't replace the service's prized "combat aircraft." Not counting Predators and Reapers as combat aircraft, however, ignores the fact that these two aircraft are the top-requested air assets in Iraq and Afghanistan and have flown more combat hours than any other platform in the Air Force's inventory over the last decade. The Air Force's most-valued "combat aircraft," the F-22, has yet to fly a single combat sortie.

The Air Force remains stubbornly reluctant to enforce tradeoffs with its manned fleet to facilitate the adoption of unmanned aircraft. Instead of adopting more unmanned aircraft to satisfy Gates's request for more ISR, the Air Force purchased 37 MC-12s, a manned aircraft that basically does the same mission as the Predator even though it costs three times as much.[828]

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825 The list grows to 11 if aircraft-related programs are included; the Advanced Medium-Range Air-to-Air Missile ranks 16th on the list. Peter W. Singer, "U-Turn," *Armed Forces Journal*, April 2011, available at http://www.armedforcesjournal.com/2011/04/5787503

826 Rebecca Grant, "In Defense of Fighters," *Air Force Magazine*, July 2002, available at http://www.airforce-magazine.com/MagazineArchive/Pages/2002/July%202002/0702fighter.aspx.

827 United States Air Force FY 2011 Budget Estimates, February 2010, available at http://www.saffm.hq.af.mil/shared/media/document/AFD-100128-072.pdf. The Air Force spent $5.3 billion (p. F-2) to procure manned "combat aircraft" versus $667 million to procure additional Predators and Reapers (p. F-6).

828 The unit cost of an MC-12 is $17 million [see Air Force Fact Sheet, available at http://www.af.mil/information/factsheets/factsheet.asp?id=15202]. A Predator costs $4.5 million [Christopher

Moreover, it takes three times as many MC-12 sorties to provide the same coverage as one Predator mission. When announcing the MC-12 program, Major General Bradley Heithold, commander of the Air Force Intelligence, Reconnaissance and Surveillance Agency, said, "There is something special, if you will, about a manned ISR platform."[829] In an effort to justify the purchase, Heithold, who had previously served on AC-130 gunships, said "there are strong bonds between those fighting on the ground and the crews in the air supporting them … Because you're not going to leave those people on the ground until you are out of fuel or out of bullets."[830] Heithold's comments are somewhat curious given the fact that Air Operations Center commanders (those in charge of managing an air war), not to mention the crews operating unmanned aircraft, have demonstrated a track record of being more, not less willing to sacrifice an unmanned aircraft for the sake of those on the ground. The reason why is obvious—no casualties.

Hoping to arrest the declining number of manned fighters, top Air Force leaders also took to the press to warn of the "erosion of America's air dominance as more advanced aircraft and missiles proliferate."[831] Senior Air Force generals claimed the nation was facing a potentially catastrophic shortage of manned fighter aircraft. They alleged the Air Force's share of the shortage will balloon to 800 by 2024.[832] Gates dismissed the Air Force's talk of a "fighter

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Drew, "Drones Are Weapons of Choice in Fighting Qaeda," *New York Times*, 16 March 2009, available at http://www.nytimes.com/2009/03/17/business/17uav.html?_r=3].

829 Stew Magnuson, "Ground Forces Still Want Manned Surveillance Aircraft, General Says," *National Defense, January 2010*, available at http://www.nationaldefensemagazine.org/archive/2010/January/Pages/GroundForcesStillWantMannedSurveillanceAircraft,GeneralSays.aspx.

830 Ibid.

831 Greg Gant, "Gates Dismisses Fighter Gap," *DoD Buzz: Online Defense and Acquisition Journal*, 16 September 2009, available at http://www.dodbuzz.com/2009/09/16/gates-dismisses-fighter-gap.

832 Erik Holmes, "Officials: Fighter Gap Could Reach 800 Planes," *Air Force Times*, 9 April 2008, available at http://www.airforcetimes.com/news/2008/04/airforce_fighter_gap_040908w.

gap" as "nonsense."[833] Instead, Gates suggested the "more compelling gap" is the "deep chasm" that exists between ever-more capable U.S. aircraft and those of other nations that will ensure U.S. air supremacy far into the future.[834] Gates also declared that Air Force talk of a "fighter gap" was a myth based on "dated assumptions about requirements and risk."[835] After the Government Accountability Office (GAO) compared the Air Force's claim to the data, Air Force officials admitted they "intentionally excluded" the capability that unmanned aircraft provided in their analysis.[836] They insisted their computer programs "would not recognize [unmanned aircraft] as having adequate capabilities to address the high-end threat scenarios."[837] Air Force officials stated the "primary driver in Air Force requirements is the ability to operate in anti-access and contested environments and unmanned aircraft are limited to operating in permissive environments. Therefore, they are not viewed as replacements for manned tactical aircraft, but instead as complementary capabilities."[838] Disagreeing with the Air Force's claim, the GAO told the Air Force it needed to articulate how systems like unmanned aircraft offset manned fighter requirements.[839]

Despite the GAO's guidance, Air Force officials continue to maintain that unmanned aircraft will not encroach significantly upon manned missions. They are, for example, careful not to position the MQ-X as encroaching upon any manned platform, particularly the JSF,

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833 Greg Gant, "Gates Dismisses Fighter Gap," *DoD Buzz: Online Defense and Acquisition Journal*, 16 September 2009, available at http://www.dodbuzz.com/2009/09/16/gates-dismisses-fighter-gap.
834 Ibid.
835 Ibid. Moreover, this view neglects to consider how unmanned aircraft technology is advancing, therefore making it more survivable in a high-threat environment. Consider, for example, the stealthy, jet-powered RQ-170. The RQ-170 has been operational for years.
836 Government Accountability Office, "Tactical Aircraft: DOD's Ability to Meet Future Requirements Is Uncertain, with Key Analyses Needed to Inform Upcoming Investment Decisions," July 2010, 6, available at http://www.aviationweek.com/media/pdf/Check6/GAO_Tactical_Aircraft_Report_July_2010.pdf.
837 Ibid.
838 Ibid, 8.
839 Ibid.

despite the fact that the MQ-X is still in the requirements-definition phase and industry is offering many different MQ-X concepts that offer various capabilities. The Air Force's Unmanned Aircraft Systems (UAS) Flight Plan suggests only the broad goal of developing "unmanned aircraft systems [that] are considered as viable alternatives to traditionally manned platforms."[840] Securing a stronger statement was politically untenable. The Air Force's UAS Flight Plan champions the idea of manned-unmanned teaming, giving the F-22 and the JSF unmanned wingmen, a concept congruent with the Air Force's position that unmanned aircraft will supplement rather than replace manned aircraft.[841]

Right before Gates left his post as Secretary of Defense, he again chastised the Air Force's for its resistance to unmanned aircraft, saying the service needs to recognize "the enormous strategic and cultural implications of the vast expansion in remotely piloted vehicles."[842] He warned that the Air Force will likely "resist change" once he leaves (i.e., in the absence of a strong visionary leader), reverting to a Cold War-era focus on fighter jets and bombers at the expense of drones and other new weapons.[843] "The view still lingers in some corners that, once I depart as secretary and once U.S. forces draw down from Iraq and Afghanistan in accordance with the president's and NATO's strategy, things can get back to what some consider to be real Air Force normal," Gates said. "This must not happen."[844]

Four factors may offset resistance within Air Force leadership to embracing unmanned aircraft. First, as noted above, the technological trajectory of unmanned aircraft appears

[840] U.S Air Force, *United States Air Force Unmanned Aircraft Systems Flight Plan 2009-2047*, available at http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA505168.
[841] Ibid.
[842] David Lerman, "Gates Says U.S. Air Force May Resist Change Once He Leaves," *Bloomberg*, 4 March 2011, available at http://www.bloomberg.com/news/2011-03-04/gates-says-he-fears-air-force-will-resist-change-once-he-leaves.html.
[843] Ibid.
[844] Ibid.

poised to increasingly shift relative advantage in the weapon's favor. Moreover, in the near future, that trajectory may receive a substantial boost from commercial research and development. The Federal Aviation Administration (FAA) Modernization and Reform Act of 2012 mandated that the FAA establish procedures to open national airspace to unmanned civil and commercial aircraft by 2015.[845] Currently, the FAA denies civil unmanned aircraft access to national airspace expect in very limited circumstances.[846] The legislation alleviates restrictions that have heretofore inhibited commercial UAV applications, and market analysts expect an explosion of commercial research and development. For example, FedEx and UPS have expressed interest in using unmanned vehicles for long-haul cargo duty and are exploring the development of air corridors for cargo UAVs.[847] It is important to note that commercial innovation has underwritten much of the military fixed-wing and rotary-wing innovation over the last century.

The second factor can be summarized in one word: demographics. Skyrocketing complexity and costs of fighter aircraft, the product of perennial sustaining innovation, has contributed to a sharp decline in fighter numbers. From a post-Vietnam war high of approximately 4,000, the Air Force's fighter inventory has dropped nearly fifty percent,

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845 The FAA Modernization and Reform Act of 2012 is available at http://www.gpo.gov/fdsys/pkg/CRPT-112hrpt381/pdf/CRPT-112hrpt381.pdf.

846 The FAA confines drones operated by the defense department and other government department to restricted airspace. Government agencies can pursue special permission for operations outside restricted airspace through the Certification of Authorization process to obtain a waiver that permits narrowly defined flight operations for a limited period of time. From experience, the process is broken. Flight approvals can take upwards of a year.

847 The Joint Planning and Development Office, "UAVs Coming Soon to a Sky Near You," http://www.jpdo.gov/newsArticle.asp?id=14. See also Lee Moak, "Unmanned Aerial Vehicles, FedEx Joint Council Meeting" (speech, Air Lines Pilots Association Joint Council Meeting, Memphis, TN), 24 August 2011, available at http://alpatv.alpa.org/ALPAChannelPlayer/TabId/404/VideoId/511/Captain-Lee-Moak-Topic-Unmanned-Aerial-Vehicles-FedEx-Joint-Council-Meeting.aspx.

weakening the dominant subculture's constituency.[848] Fighter numbers will continue to shrink because the Air Force cannot afford to replace its fourth generation aircraft on a one-for-one basis. Moreover, given JSF's non-affordability and the program's track record, significantly fewer fighters than currently planned are likely to be acquired. Additionally, assuming unmanned aircraft shoulder expanded roles, fiscal austerity to help reduce the nation's deficit may quicken the decline in fighter numbers.[849] As money becomes tighter, political pressure may mount to enforce tradeoffs.

Perhaps the decline in manned bomber numbers after the adoption of the intercontinental missiles (ICBMs), another form of unmanned airpower, informs the pace of the transition from manned to unmanned aircraft. The number of manned bombers in the Air Force's inventory nosedived from 2,194 in 1960, the year the first ICBM became operational, to 497 in 1975, a 77% drop. Whereas bomber pilots once held a majority, by 1975 fighter pilots outnumbered bomber pilots four to one.[850] Bomber pilots managed to hold on to the top leadership position within the Air Force for seven more years, but the sharp decline in bomber numbers undercut bomber pilots' institutional power.[851]

A similar demographic shift is occurring between the manned and unmanned communities. Fast-paced UAV growth over the last decade caused the unmanned community

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[848] See Figure 7, Chapter 2.

[849] Echoing former Secretary of Defense Robert Gates's consistent observation that adding layer upon layer of cost and complexity onto fewer and fewer platforms that take longer and longer to build must come to an end (see Chapter 1), Robert Hale, the Defense Department comptroller, warned the armed services that they must shift away from seeking "99 percent 'exquisite' systems," which take too long to develop and build, and then can be deployed only in very limited quantities because of their exorbitant costs [U.S. Department of Defense, *United States Department of Defense Fiscal Year 2012 Budget Request*, February 2011, 4-2, available at http://comptroller.defense.gov/defbudget/fy2012/FY2012_Budget_Request_Overview_Book.pdf].

[850] Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945–1982* (Maxwell AFB, AL: Air University Press, 1998), 223.

[851] The long rule of bomber pilots, the masters of apocalyptic destruction, was swept away by the forces of creative destruction.

to balloon into the second largest group of aviators in the Air Force—only the F-16 community has more pilots. The service now trains more crews to operate unmanned aircraft than it does to fly manned fighters or bombers.

Third, international competition over drones may entice the Air Force to continue to innovate. Roughly fifty nations, with more joining every month, are either buying or building unmanned aircraft.[852] Some are allies but many are either current or potential adversaries like Iran, Pakistan, China, and Russia.[853] The erosion of the United States' near monopoly on armed drones may lead to a drone arms race.[854] China, for example, a country that unveiled its first concept UAV in 2008, has been making huge strides in UAV design. To the surprise of western defense officials and experts, it showed off 25 different models of unmanned aircraft, a record number, at a recent airshow.[855] China has been ramping up production of UAVs in a bid to catch up with the United States.[856] While likely an overstatement, China's rapid UAV development has led some intelligence analysts to assert that the Asian nation has nearly achieved that goal and closed the UAV gap with the U.S.[857]

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[852] Scott Shane, "Coming Soon: The Drone Arms Race," *New York Times*, 8 October 2011, available at http://www.nytimes.com/2011/10/09/sunday-review/coming-soon-the-drone-arms-race.html?pagewanted=all.
[853] Jennifer Rizzo, "Drones Soar in U.S. Plans for Future Aircraft Purchases," *CNN*, 10 June 2011, available at http://articles.cnn.com/2011-06-10/us/pentagon.drones_1_drone-strikes-unmanned-aircraft-global-hawk/2?_s=PM:US.
[854] Scott Shane, "Coming Soon: The Drone Arms Race," *New York Times*, 8 October 2011, available at http://www.nytimes.com/2011/10/09/sunday-review/coming-soon-the-drone-arms-race.html?pagewanted=all.
[855] Jeremy Page, "China's New Drones Raise Eyebrows," *Wall Street Journal*, 18 November 2010, available at http://online.wsj.com/article/SB10001424052748703374304575622350604500556.html. The *Wall Street Journal* reports, "The Chinese drone of greatest potential concern to the U.S. is the one with several missiles and a jet engine—called the WJ600—which was displayed by China Aerospace Science & Industry Corp., or Casic, one of China's top weapons makers. Casic officials declined to comment, but a video and a two-dimensional display by the company showed Chinese forces using the WJ600 to help attack what appeared to be a U.S. aircraft carrier steaming toward an island off China's coast that many visitors assumed to be Taiwan" [Ibid].
[856] Ibid. See also William Wan and Peter Finn, "Global race on to match U.S. drone capabilities," *Washington Post*, 4 July 2011, available at http://www.washingtonpost.com/world/national-security/global-race-on-to-match-us-drone-capabilities/2011/06/30/gHQACWdmxH_story.html.
[857] "The UAV Arms Race between China and the US," available at http://www.defense-parts.com/wordpress/2011/07/07/unmanned-drones-change-aircraft-systems-in-us-and-china.

Fourth, interservice competition may intensify.[858] The Army has unswervingly used disruptive weapons that blur roles and mission boundaries—first adopting helicopters and later UAVs— to skirt restrictions on rebuilding its organic airpower fleet (see Chapters 4 and 5). The next section details Army UAV expansion plans, but it is informative to first review the Army's historical commitment to expand its air forces. A 1970 Rand report concluded:

> Over the years, qualitative and quantitative Army requirements stimulated development of a variety of small conventional aircraft, and especially of advanced helicopters. The acquisition of these aviation capabilities provided the Army with an entrée into the CAS mission area that manifested itself in the actual performance of some CAS tasks. Employment of these Army capabilities thus brought about de facto changes in missions and functions while the basic missions and functions directives remained unchanged.[859]

Furthermore, the Rand Report observed:

> Issues with important implications for roles and missions have been decided on a narrow basis rather than within a context of roles and missions. … Thus, decisions have been made on weapon systems, logistics, specific tactical tasks, development responsibilities, training, testing, and a host of other aspects of the aviation function. This piecemeal approach has served to effect de facto changes in the missions that were never incorporated in roles and missions declarations. The cumulative and accelerating effect of these decisions has been to foster the growth of Army aviation quantitatively, qualitatively, and functionally.[860]

When questioned during 1971 Senate hearings on whether the Army's use of advanced helicopter gunships encroached upon the Air Force's assigned close-air-support function, Secretary of the Army Robert Froehlke responded, "I think that a helicopter and fixed wing is as good a line as you can draw. I think it is a sensible arrangement whereby we say the organic

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[858] Although not a focus of the UAV case study in Chapter 5, the Navy, albeit belatedly, is showing surging interest in UAVs. For example, it first flew the X-47B, a jet-powered, carrier-capable, stealthy Unmanned Combat Aerial Vehicle demonstrator, in 2011 and plans sea trials in 2013. Similar to the Air Force's experience, the entrenched interest of carrier pilots, a dominant subculture, remains a formidable obstacle. Nonetheless, the Navy is becoming increasingly interested in UAVs.
[859] Alfred Goldberg and Donald Smith, "Army-Air Force Relations: The Close Air Support Issue," RAND Project Air Force report, October 1971, 43.
[860] Ibid, 44-45.

Army unit will be helicopter, the Air Force will have fixed wing."[861] Air Force General William Momyer, the commander of Tactical Air Command (TAC), accurately predicted that the Army would not adhere to the division. He recognized that technology would not remain static and that the Army would continue to make incursions into what he perceived as the Air Force's airpower roles-and-missions domain as helicopters advanced. "I am sure that after the Cheyenne—an army aviator is no different than any other aviator," protested Momyer. "He is going to want to go faster; he is going to want to go farther and he is going to want to carry more [firepower]."[862] Senator Symington agreed with Momyer's testimony, saying that it was "clear as light" that an effort was underway "to usurp the assigned mission of ground support the Air Force was given in the Key West agreement.[863]

Momyer and Symington's predictions proved accurate. The Army emerged from the Vietnam War with even greater determination to expand its organic air capability.[864] By 1991, in terms of the number of aircraft in its inventory, of which the vast majority were rotary wing, the U.S. Army ranked as the third largest air force in the world, after the U.S. Air Force and the Soviet Union's aviation forces.[865] Today, the U.S. Army maintains the largest and most sophisticated helicopter force in the world. Helicopters have become the aviation workhorse of the Army, performing a full complement of missions, everything from transport to gunship.

Army

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[861] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: Air Force History and Museums Program, 1989), 220.
[862] Ibid.
[863] Ibid.
[864] Morton H. Halperin, Priscilla Clapp, and Arnold Kanter, *Bureaucratic Politics and Foreign Policy* (Washington, DC: Brookings Institute, 1974), 46.
[865] Richard A. Leyes and William A. Fleming, *The History of North American Small Gas Turbine Aircraft Engines* (Reston, VA: American Institute of Aeronautics and Astronautics, 1999), 160.

While it took the intervention of Robert Gates to accelerate the adoption of unmanned aircraft within the Air Force, the Army leadership orchestrated an exponential expansion of unmanned aircraft within its own ranks. Indeed, the Army reached a million unmanned flight hours almost a year before the Air Force.[866] Unlike the Air Force's UAV plan, the Army's Unmanned Aircraft Systems (UAS) Roadmap envisions a "dramatic shift to a nearly all-unmanned flight over the next three decades" (see Figure 16).[867] The plan calls for UAVs to become the Army's mainstay aviation force while manned aircraft are relegated to fulfill two niche roles: medevac and utility. Certainly, the Army faces the same challenge with its own manned aviators as the Air Force does with its entrenched interests; both communities are understandably resistant to the change. Notably, the Army's plan also includes an intermediate step of teaming unmanned aircraft with Apache attack helicopters. But unlike fighter pilots in the Air Force, the rotary-wing constituency in the Army is not the dominant subculture and has less power to obstruct the transition. After its experience with its original group of airmen, those who broke away to form an independent Air Force, the Army decided to fill its cockpits largely with warrant officers rather than line officers. The effect, by design, was to neuter the rotary-wing constituency's power. Now that unmanned aircraft technology has become part and parcel of everything the Army does, the dominant combat branches within the Army,

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866 The Army hit the one million hour mark in May 2010 [C. Todd Lopez, "Army Hits 1 Million Flight Hours With Unmanned Aircraft," U.S. Army News Service, 27 May 2010, available at http://www.army.mil/article/39902]. The Air Force did not reach the one million hour mark until March 2011 [Tu-Uyen Tran, "Demand for Unmanned Aircraft "Insatiable,'" *Air Force Times*, 11 June 2011, available at http://www.airforcetimes.com/news/2011/06/ap-demand-for-unmanned-aircraft-insatiable-061111].

867 Stephen Trimble, "US Army Predicts Shift to Nearly All Unmanned Aircraft by 2035," *Flight International*, 16 April 2010, available at http://www.flightglobal.com/articles/2010/04/16/340692/us-army-predicts-shift-to-nearly-all-unmanned-aircraft-by.html.

infantry and armor, have strong interest in completing the transition.[868] Unmanned aircraft technology has totally changed the way the Army fights.[869] The transition to unmanned aircraft within the Army is already well underway—UAVs now account for forty percent of the Army's flying hours, up from around four percent less than a decade ago.[870]

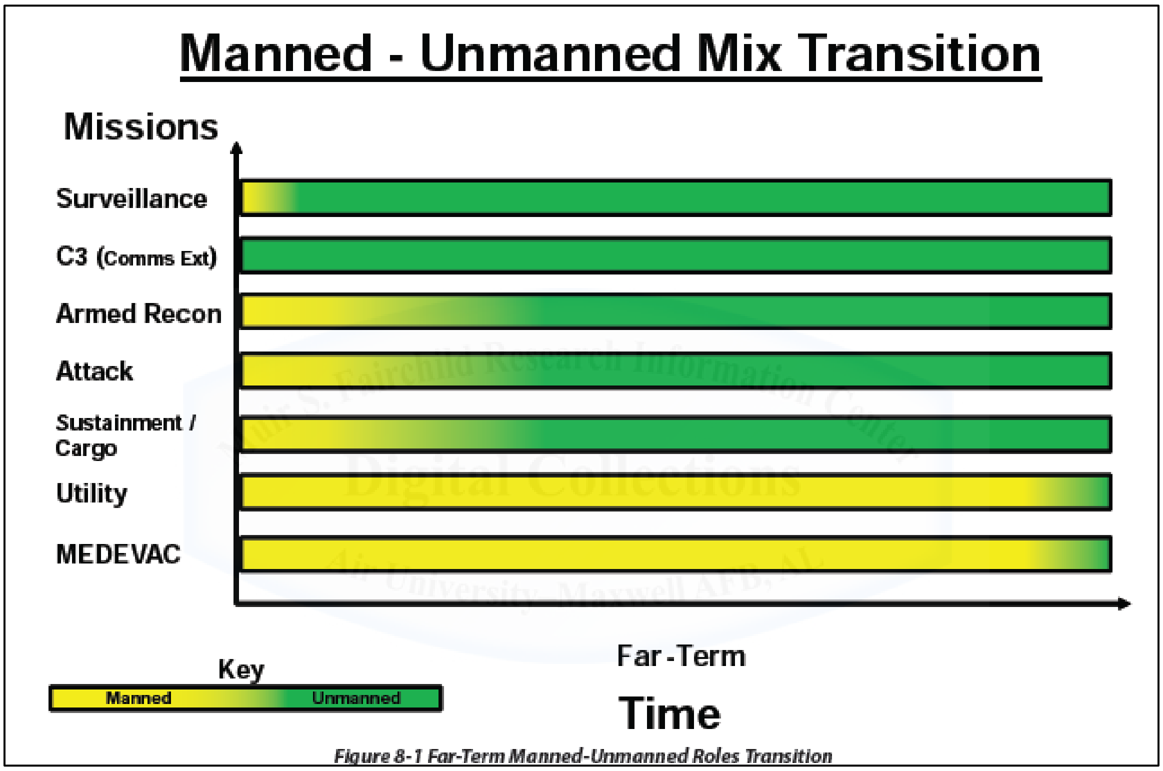

FIGURE 16 – U.S. Army’s Predicted Manned-Unmanned Mix[871]

[868] Andrea Shalal-Esa, “Firms Vie for Share of Growing Unmanned Plane Market,” *Reuters*, 11 August 2009, available at http://www.reuters.com/article/2009/08/11/us-pentagon-unmanned-idUSTRE57A6FK20090811.
[869] Ibid.
[870] Ibid.
[871] Source: *U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035*, June 2010, 60, available at http://www.fas.org/irp/program/collect/uas-army.pdf.

POLICY IMPLICATIONS

This study has four important policy implications. First, because perennial sustaining innovations, at some point, tend paradoxically to produce new generations of weapons with diminishing relative advantage, a military organization's enduring relevance depends on its leaders' "willingness to cannibalize." The challenge is that adopting disruptive innovations, by definition, requires a service to destroy, reinvent, or redirect an important part of itself.[872] Adopting new classes of weapons can be especially painful and difficult for dominant subcultures when it involves executing a death warrant for existing weapons from which they gain their identifies. Nevertheless, as General Eric Shinseki, former U.S. Army chief of staff, observed, "If you dislike change, you're going to dislike irrelevance even more."[873] Staying wedded to existing weapon systems effectively conjoins a military organization's future to that weapon system's life cycle. In the extreme, that can lead to functional obsolescence and extinction.[874]

U.S. Air Force leaders are currently wrestling with the question of whether sustaining innovations to manned aircraft have reached a point of diminishing returns and whether pursuing unmanned aircraft offers a better alternative. In other words, does acquiring ever-more-perfected versions of manned aircraft like the Joint Strike Fighter, a plane that if procured will become the most expensive weapon system in history, represent the best strategic choice

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[872] In the case of the helicopter, General William Westmoreland, the general who commanded US military operations in the Vietnam War from 1964–68 and later served as the Army's chief of staff from 1968-1972, states, "The Army traded off tanks and howitzers for the capability of raising part of its fire support means a few feet above the terrain and providing it with a significant increase in speed and maneuverability."
[873] Harold Biernman and Seymour Smidt, *The Capital Budgeting Decision: Economic Analysis of Investment Projects* (New York, NY: Routledge, 2006), 231.
[874] For example, the Samurai could not break free from their cultural connection to the sword, a weapon which served them well for centuries, and were confined to the dustbin of history after gunpowder made sword-fighting obsolete.

for the institution or the nation?[875] Or do the unmanned aircraft represent the future of airpower? The answer is complicated by the fact that adopting more UAVs to perform more missions may be in the long-term institutional interest of the Air Force and the best interest of the nation, but it is not in the best interest of the dominant subculture, fighter pilots.[876]

During a speech to the Air Force Historical Foundation, General Norton Schwartz, the U.S. Air Force chief of staff, insightfully observed that his service faces a remarkably similar choice to one it confronted fifty years ago. "There was a time when some in our Air Force thought that missiles and other unmanned vehicles were not a good fit into our core mission, and thus had no place in our Service," remarked Schwartz.[877] "We are at another one of those points of inflection. Now, it is clear that we must reconsider the relationship between people, machines, and the air. The technology that initially allowed us to slip 'the surly bonds of Earth' has progressed to the point where pilots on the ground can now remotely operate highly capable, highly maneuverable, and highly versatile unmanned vehicles."[878] In highlighting the ICBM story, the general hoped to impress upon his service the following point: "Those who are able to capture and embrace technology have a significant advantage over those who have not."[879]

Schwartz, an advocate of an increasingly "unmanned" Air Force, suggested his service should use lessons from its ICBM experience to guide its UAV development and adoption

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[875] Lee Ferran, "F-35 Fighter: Price Goes Up $771 Million on Most Expensive Defense Program," *ABC News*, 14 July 2011, available at http://abcnews.go.com/Blotter/lockheed-martin-35-fighters-cost-771/story?id=14071402.
[876] By definition, disruptive innovation requires a service to destroy, reinvent, or redirect an important part of itself, and that can mean the toppling of a service's internal hierarchy.
[877] Norton Schwartz, "The Balkans Air Campaigns and Their Influence Since 2001" (speech, Air Force Historical Foundation, Washington, DC), 8 October 2009, available at http://www.af.mil/shared/media/document/AFD-091102-163.pdf.
[878] Ibid.
[879] Ibid.

decisions: "History, in all its aspects – good and bad – informs our efforts today. We [must] seek to learn from our shortcomings, and to avoid them in the future; but, the storied history of the United States Air Force suggests that much of what we have done are things that we do want to repeat."[880] The general was referring to the example set by Thomas White. White recognized that adopting the ICBM meant a diminished role for the manned nuclear bomber, yet he did so for broader reasons of national security rather than to protect entrenched service interests. He told the Air Staff on many occasions that "the build-up in strategic missiles such as the Atlas, Titan, and Minuteman was not good for the *traditional* Air Force but it was vital for the nation" (emphasis added).[881] In contrast, Curtis LeMay wanted to conjoin the Air Force's future to the manned nuclear bomber; at one point, he advocated doing away with all conventional TNT ordnance in the Air Force's inventory and transitioning exclusively to nuclear bombs carried by manned bombers.[882] If the Air Force had followed the path LeMay advocated, the service would have become much less relevant. Not only did embracing the ICBM allow the Air Force to play a leading deterrence role in the Cold War, fulfilling the primary national security objective of the United States, it put the service on the path to dominate military space operations, an activity that constitutes an increasingly important source of asymmetric advantage for the United States.

Similarly, the Air Force preserved much of its relevance over the last decade precisely because Ron Fogleman compelled the Air Force to steal the Predator away from the Army; and

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[880] Ibid.
[881] Warren A. Trest, *Air Force Roles and Missions: A History* (Washington, DC: U.S. Government Printing Office, 1988), 190.
[882] To his credit, LeMay would eventually embrace missiles after the disruptive technology matured, although he would remain forever partial to the manned nuclear bomber.

John Jumper, Robert Gates, and Norton Schwartz helped accelerate the technology's adoption within the service's ranks. One historian notes:

> It is hard to think of another airplane since the B-17 Flying Fortress of World War II whose name would become such a household word that mere mention of the word conjured up, not just an airplane nor even a whole class of warplanes, but a revolutionary new concept in military operations. Even people who could not pick a General Atomics RQ/MQ-1 out of a line-up have heard the phrase "Predator drone" in the media, and know what it means.[883]

Unmanned aircraft have proved invaluable over the last decade, changing the way wars are fought.[884] The wars in Afghanistan and Iraq have been defined by the use of unmanned systems, much the same way that Vietnam became known as the helicopter war.[885] In contrast, the current wars have made the Air Force's "most-capable" high-performance manned combat aircraft appear impotent and irrelevant.

The second policy implication comes from the following observation: all three cases examined in this study illustrate the critical role that leaders play in weapon system innovation. Neither military leaders nor civilians seemed to hold a monopoly on the power to effect change; both served as agents of change. However, those in uniform serving in positions of power within the armed serves seemed to hold the reins of innovation, while civilians appeared most effective in reinforcing and accelerating the adoption of new classes of weapons after the services began to embrace them. Civilians also played a significant role in enforcing tradeoffs.

One way to encourage disruptive innovation, especially when it threatens the dominant subculture, is to appoint an "outsider," someone not beholden to the dominant subculture, as

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883 Bill Yenne, *Birds of Prey: Predators, Reapers and America's Newest UAVs in Combat* (North Branch, MN: Specialty Press, 2010), 37.

884 Travis Burdine, "The Army's 'Organic' Unmanned Aircraft Systems," *Air & Space Power Journal*, June 2009, available at http://www.airpower.maxwell.af.mil/airchronicles/apj/apj09/sum09/burdine.html.

885 Andrea Shalal-Esa, "Firms Vie for Share of Growing Unmanned Plane Market," *Reuters*, 11 August 2009, available at http://www.reuters.com/article/2009/08/11/us-pentagon-unmanned-idUSTRE57A6FK20090811.

chief of staff. Although White's ascension to the top job within the Air Force was more luck than a deliberate effort to encourage innovation, his tenure nevertheless illustrates the benefits of having a chief whose background made him more willing to discount organizational costs associated with adopting the ICBM.[886] Unlike LeMay, White's professional success and identity were not linked to the manned nuclear bomber; he had spent little time in the "traditional" Air Force. White's career took him to diplomatic and legislative affairs positions around the globe, undoubtedly improving his political savvy and skill which he used to politically outmaneuver LeMay. White appointed LeMay his vice, taking to heart the adage: "Keep your friends close, and your enemies closer."[887] Norton Schwartz provides another example of an "outsider" who proved willing to embrace disruptive innovation at the expense of the dominant subculture's weapon of choice. Schwartz, the first non-fighter or bomber pilot Air Force chief of staff, quelled dissension over Secretary Robert Gates's decision to curtail F-22 production and helped facilitate the exponential expansion of UAV operations. The successes of White and Schwartz suggest that an effective way to encourage the Air Force to institutionalize unmanned aircraft is to appoint a non-aviator to run the service.

The third policy implication follows from recognition that sustaining innovation remains the norm, yet a military organization's enduring effectiveness depends on adopting disruptive innovation to refresh its relevance. Currently, the U.S. military spends the vast majority of its funding to procure and improve existing weapons. The armed services may want

[886] Nathan Twining, the "accidental" third chief of staff of the U.S. Air Force, was scheduled to retire as a three star general but rose to the throne after both Hoyt Vandenberg's deputy and Vandenberg himself fell ill. Twining unexpectedly chose White as his vice chief, interrupting the succession of LeMay to the top spot. See Chapter 3.
[887] The saying "Keep your friends close, and your enemies close" is normally attributed to Sun-Tzu, a Chinese strategist who lived in 400 BC. White may have taken the approach to heart during his assignment to China as a military attaché. Not only did LeMay work for White, he also lived next door. White and LeMay lived side-by-side in a duplex on Fort Myer, VA.

to reexamine that practice and perhaps fence off more money for research and development for disruptive innovations. Granted, military leaders must balance their force-in-being requirements with the needs of the future, yet the ratio between sustaining and disruptive spending appears unbalanced.

The last policy implication of this study hinges on the Air Force's willingness to provide UAV leadership. Unmanned aircraft technology has allowed the Army to bypass barriers to acquiring an organic fixed-wing air force. As such, it has allowed the Army to re-attack fundamental questions about who should own and control airpower as well as how it should be employed. The fighter-dominated Air Force leadership has a strong incentive to cede the UAV initiate to the Army since doing so would afford the junior service the opportunity to sustain a familiar form of warfare, manned aerial operations, and continue tackling problems it prefers to solve.[888] Furthermore, ceding UAV leadership to the Army would allow the Air Force to narrow the institution's focus on the higher-end missions that fighter pilots, the dominant subculture, care most about. A UAV retreat, however, may prove myopic. In the long run, it could lead to shrinking Air Force roles and responsibilities, a smaller budget share, and diminished organizational relevance.

In conclusion, the outcome of the apparent unmanned revolution in airpower, because it will influence who owns and controls airpower, may have far reaching consequences for airpower and American security. As outlined earlier, the Army and Air Force have fundamentally different approaches to airpower. If the Army continues to embrace unmanned aircraft while the Air Force bows to institutional resistance and proves "unwilling to

[888] Thomas Ehrhard, "Integrating Disruptive Technologies in DoD … A Bridge Too Far?" (presentation, 5th Annual Disruptive Technologies Conference, Washington, DC, 4 September 2008).

cannibalize," the nation will have an unmanned air force that supports its Army. At times, this is exactly what the country needs, but in other situations, not. There are times when airpower, manned and unmanned, must transcend the support of individual ground units to accomplish theater-wide or global objectives. This is the legacy of Kasserine Pass and one of the reasons the United States has an independent Air Force with the experience, focus, and expertise to serve all of the nation's airpower needs, including those of its Army. The unmanned revolution will eventually visit all of the services and most of their weapon systems. American security demands proper stewards. Just as the Air Force stepped up to strategic bombing and ICBMs in the Cold War, and as the Army played the leading role in counterinsurgency for the war on terrorism, the service whose business is to command the skies and fly, fight, and win, should be the principal in unmanned aviation.

FUTURE RESEARCH

Although the cases investigated in this study reveal that the new, cross-disciplinary framework adds value, the dissertation's scope was limited to post-World War II airpower-related weapon system innovation. Accordingly, future research could expand the scope of the investigation both temporally and topically. For example, does the new, cross-disciplinary framework help explain airpower-related innovations prior to WWII? As noted in the dissertation, the helicopter and the UAV's paths to adoption seem to mirror that followed by manned aircraft, thus making the avenue of investigation appear promising. Nevertheless a more definitive study is required to determine, with confidence, whether the new, cross-disciplinary model helps explain airpower innovations in an earlier era. Additionally, future

research may want to explore whether the new, cross-disciplinary model applies to naval- and land-warfare-related weapon system innovations. A cursory review of the U.S. Navy's adoption of the steamship, the most important naval innovation of the nineteenth century, suggests that it may also provide a promising avenue of investigation. The new, cross-disciplinary model seems to provide a better explanation than the theories of Coté, Rosen, and Posen (see Appendix A).[889]

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In closing, the results of this investigation suggest is worthwhile for uniformed leaders to reflect upon the sage advice contained in the opening quote of Chapter 2 (modified for a military context):

> [To remain relevant, military organizations must break free from a pattern] of using yesterday's bag of tools to solve tomorrow's problems. They must do so today, while they still have options, not tomorrow, when they have nothing left but a useless bag of tools. They must be willing to cannibalize before there is nothing of value left to cannibalize.[890]

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[889] Steamships displaced sailing ships, the dominant naval vessel since time since time immemorial.

[890] See opening quote of Chapter 2. Rajesh K. Chandy and Gerard J. Tellis, "Organizing for Radical Product Innovation: The Overlooked Role of Willingness to Cannibalize," *Journal of Marketing Research* Vol. XXXV, November 1988, 485.

APPENDIX A

THE U.S. NAVY'S ADOPTION OF THE STEAMSHIP

The new, cross-disciplinary model proposed in this study appears to provide a better explanation for the U.S. Navy's adoption of the steamship, the most important naval innovation of the nineteenth century, than the theories developed by Owen Coté, Stephen Rosen, and Barry Posen.

The Insufficiency of Coté, Rosen, and Posen

Coté's interservice rivalry theory does not apply; the steamboat technology was of interest to one service, the Navy.[891] Moreover, in the nineteenth century, the Navy and Army were two separate departments; rarely did they conduct joint operations and, hence, the two services were seldom concerned with each other's business.

Likewise, Posen's civilian intervention theory does not adequately explain when and why the Navy adopted the steamship, something that occurred despite, not because of, the service's civilian leadership. Steamships in naval service began to experience exponential growth during the tenure of Secretary of the Navy James K. Paulding, 1938-1941.[892] Paulding was quite hostile to the idea of steam propulsion, declaring that he would "never consent to let

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[891] Samuel P. Huntington makes the argument: "Interservice rivalry was the child of unification. Both reflected the unity and complexity of modern war, and without the one, the other would never have come into existence" [Samuel P. Huntington, "Interservice Competition and the Political Roles of the Armed Services," *The American Political Science Review,* Vol. 55, No. 1, March 1961, 40-41]. Even if one disagrees with Huntington's assessment that interservice competition was the product of World War II, no evidence suggests the Navy's adoption of the steamboat was a product of interservice competition.

[892] "The introduction of steamships into our navy did not assume much importance until the administration of Secretary [James K.] Paulding, 1838-1841" [Charles Oscar Paullin, "Naval Administration Under the Navy Commissioners, 1815-1842," *Proceedings* Vol. 33, Part I, No. 122 (Baltimore, MD: The Lord Baltimore Press, 1907), 617].

our old ships perish, and transform our navy into a fleet of sea monsters."[893] Additionally, in that era, it was not necessarily commonplace for senior civilians to intervene forcefully in military affairs and impose their will over senior military officers. "The head of the Navy Department is generally a politician, more solicitous to obtain popularity among the officers than competent to discharge judiciously the functions of his office," remarked a Navy historian. "He listens, therefore, to the advice of the superannuated officers, who, with professional dogmatism, denounce all novelties and pronounce all innovations dangerous."[894] In an 1839 letter, Paulding complained that he was being "steamed to death" by the people of the United States who had caught "steam fever."[895] Despite his opposition, Paulding acknowledged he was obligated to relent to their wishes and "go with the wind [because] the man who opposes the world is a fool for his pains," although he admitted he did not intend to "carry full sail [but rather] keep the steam enthusiasts quiet by warily administering to the humour of the times."[896] Paulding believed that the utility of naval steamships for deep-sea operations had yet to be demonstrated, but nonetheless, he gave in to mounting public pressure and begrudgingly authorized the construction of two side-wheel steam frigates, the *USS Mississippi* and *USS Missouri*, the Navy's first ocean-going steam-driven capital ships. Previously, the Navy had built a handful of steam ships to use in auxiliary roles.[897]

[893] William Irving Paulding, *Literary life of James K. Paulding* (New York, NY: Charles Scribner and Company, 1867), 278.
[894] Samuel J. Bayard and Robert F. Stockton, *A Sketch of the Life of Commodore Robert F. Stockton* (New York, NY: Derby & Jackson, 1856), 80.
[895] William Irving Paulding, *Literary life of James K. Paulding* (New York, NY: Charles Scribner and Company, 1867), 278.
[896] Ibid.
[897] For example, the *Demologos*, later renamed the "Fulton," functioned more as a floating steam battery used for harbor defense rather than a proper ship.

Of the three existing military innovation theories, Rosen's intraservice model provides the best explanation. Nevertheless, the underlying reason that Rosen cites as the driver of innovation—changes in a state's security situation—does not entirely explain when and why the Navy adopted steamboats.

The New, Cross-Disciplinary Model Adds Value

The perceived attributes of the steamboat better account for when and why the technology was adopted. Emblematic of disruptive innovation, early paddle-wheel steamboats grossly underperformed relative to wind-powered ships. Not only were they initially much slower, but from a military perspective, paddle wheels mounted on both sides of the ship reduced the number of cannons they could carry. Additionally, since paddle wheels extended above the waterline, they were extremely vulnerable to enemy fire. A direct hit could very well render the ship incapacitated, literally leaving it dead in the water. Moreover, early steamships were very fuel-inefficient and had to pull into port every few hundred miles to replenish their supply of coal. Predictably, none of the world's naval forces rushed to abandon their beloved sail technology. Nonetheless, steamships offered other advantages, namely their self-generated power which gave them independence from wind and tide. This allowed them to perform tasks that sailing ships could not. As a result, steamboats gradually gained traction within the military serving in an auxiliary capacity. At first, the U.S. military used steamboats in a very limited capacity, principally relying on them as troopships to ferry soldiers up rivers. By the 1820s, the technology had improved enough to afford steamboats the opportunity to expand their military role and the navy started employing steamships as tug boats. As tugs,

steamships helped major warships leave port when previously they could do so only during favorable wind and tide conditions. Despite this slight uptick, their military use remained relatively insignificant.

Meanwhile, in commercial markets, steamships continued to march “up market,” graduating from an auxiliary to a main role in maritime commerce as the technology improved. Starting in low-end inland transport routes, steamships expanded to dominate coastal trading markets. John Fincham, the author of the 1851 book *A History of Naval Architecture*, remarked, “From the time when steam navigation became appreciated … much talent and ingenuity were employed to diminish the imperfections of the machinery and the paddle-wheels, as a system.”[898] This interest helped improve commercial steamship propulsion technology to the point that steamboats became faster than sailing ships. In 1838, the oak-hulled *SS Great Western* (see Figure 17), the first steamer purposely built as a trans-Atlantic passenger liner, shattered the ocean crossing record in a race against another steamer, the *SS Sirius*. The *Sirius* actually got to New York a few hours before the *Great Western*, but it started the race four days earlier. The *Great Western* crossed the Atlantic in a remarkable 15 days. In comparison, the average westbound crossing time for vessels that were exclusively powered by sails was forty days. Moreover, the *Great Western* and *Sirius* race demonstrated the possibility of offering a relatively consistent trans-Atlantic schedule, something previously unattainable with sailing ships because, depending on the wind, tide, and sea conditions, they were often weeks or even months late. The day after the finale of the big race, an advertisement for the *Great Western’s* services that appeared in the *New York Express*, a newspaper, boasted how the ship’s speed

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[898] Ibid, 339.

brought “England nearer to us than many parts of our own country. … *Steam navigation across the Atlantic is no longer an experiment, but a plain matter of fact.* The thing has been done triumphantly” (emphasis in original).[899] In summary, the race boosted two important perceived attributes: trialability and observability.

FIGURE 17 – The *SS Great Western*, the First Purposely Built Trans-Atlantic Steamer

Despite technological progress, serious deficiencies inherent in the paddle-wheel design remained. Paddle-wheel steamships were ill-suited for rough ocean conditions, the bulky paddle-wheel boxes took up a lot of the boat’s cargo space, and poor fuel economy meant that ocean-going steamers like the *Great Western* and *Sirius* had to keep their mast, rigging, and sails in addition to their steam engines to make it across the ocean. Retaining sails helped steamships of that era take advantage of favorable wind conditions to minimize fuel consumption and provided them with a source of power if they ran out of fuel for their engine,

[899] “From the *New York Express*, April 24, Steam-Ships Sirius and Great Western: Splendid Sight from the Battery,” *Army Navy Chronicles Volume VI* (Washington City: B. Homans, 1838), 276.

a situation that nearly occurred to the *Sirius* during its race with the *Great Western*. The ship encountered unfavorable sea and weather conditions and ran out of coal. The crew burned cabin furniture, one mast, and scrap wood parts, some hacked off the boat, to limp into New York under the power of its engine.

Although the *Great Western* demonstrated great speed, the requirements for warships differed from those of commercial vessels. Fincham states, "For commercial purposes speed is usually a primary consideration. In war steamers the requirements are somewhat different; for whilst speed is *never of small consideration*, other conditions have to be connected with it ... the capability of bearing armament well, and of using it, is of course prior in importance to other qualities."[900] Technical deficiencies that hurt the sea-going qualities of steamships coupled with formidable organizational barriers to change within the military prevented the technology's adoption beyond a tipping point within the Navy. Two Navy historians wrote, "The application of steam to national ships-of war from the first was resisted by many naval officers, and had to encounter many prejudices and much opposition. It was confidently asserted by the old captains that sailing-vessels would never be superseded by steam-vessels, and that the latter would be worthless except for purposes of transportation."[901]

It took another technological advance—the screw propeller—to enable steamships to displace trans-oceanic commercial sailings ships and to push the technology beyond the tipping point within the Navy. The screw propeller offered compelling advantages over the paddle

[900] John Fincham, *A History of Naval Architecture* (London, UK: Whittaker and Co., 1851), 338.
[901] Samuel J. Bayard and Robert F. Stockton, *A Sketch of the Life of Commodore Robert F. Stockton* (New York, NY: Derby & Jackson, 1856), 81.

wheel. The following passage from *Transatlantic: Samuel Cunard, Isambard Brunel, and the Great Atlantic Steamships* explains why:

> [The screw propeller] saved weight, especially at the top of the vessel, where high paddle wheels and their machinery raised a vessel's center of gravity and made her less stable in heavy seas. It allowed for a simpler, more compact ship structure, with more space below for cargo and passengers. By eliminating the bulky paddle boxes, it offered less resistance to head winds and waves. When a ship rolled from side to side, a screw would remain submerged and moving the ship forward, unlike side paddle wheels, which could roll out of the water, alternatively racing and overloading the engine, harming machinery. Without paddle boxes, a ship would present less beam for tight maneuvers in rivers and harbors. Paddles might start a voyage too deeply immersed under a full load of coal, then rise too far out of the water as fuel was burned; a screw stayed efficiently under water regardless. Screw machinery costs less initially, and—because it was less vulnerable to passing chocks—would be cheaper and less trouble to maintain.[902]

The screw propeller was not a new idea. Its history dates back to Archimedes of Syracuse, born in 287 BC. Archimedes designed a screw system to lift water for irrigation. It would be more than two millennia later until Francis P. Smith, a British entrepreneur and inventor who lived in London, rendered the screw propeller "practically useful" for maritime propulsion.[903] In 1839, "aided by spirited capitalists," Smith built the world's first screw-propelled steamship intended for seagoing service, aptly named the *SS Archimedes*.[904] The success of the *Archimedes*, which was put through a series of sea trials in April and May of 1840, persuaded the Royal Navy to build a larger 900-ton screw-propelled steamer, the *HMS Rattler*. The Royal Navy tested the ship against the *HMS Alecto*, a specially constructed sister

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[902] Stephen Fox, *Transatlantic: Samuel Cunard, Isambard Brunel, and the Great Atlantic Steamships* (New York, NY: HarperCollins, 2003), 149. Screw steamships were cheaper than paddle wheel steamships, but not cheaper to operate than sailing ships. The cost of coal—about fifty pounds sterling per day—led the British Board of Admiralty at one point to sanction steam only when it was "necessary to use it, through the want of wind, or on account of its being unfavourable" [William Laxton, *The Civil Engineer and Architect's Journal, Volume 18* (London, UK: R. Groombridge and Sons, 1855), 170.

[903] "Minutes of the proceedings of the Institution of Civil Engineers, Feb. 13, 20, and 27, 1844," *Journal of the Franklin Institute*, Thomas P. Jones, Ed., 1844, 87.

[904] Ibid.

ship that was identical to the *Rattler* in terms of her hull and the power of her engine, but the *Alecto* was fitted with paddle wheels. The *Rattler* beat the *Alecto* in series of speed, power, and agility drills, but to remove any doubt about the overall winner of the contest, the British strapped the two vessels together stern to stern and had each proceed at full steam in a tug of war at sea. The *Rattler* out-muscled the *Alecto*, pulling it astern at over 2 ½ knots, thereby providing in a very visible demonstration its improved capability.

Immediately after the sea trials, the *Archimedes*, under the command of a Royal Navy captain accompanied by Mr. Smith, embarked on a journey to circumnavigate Great Britain. They visited nearly every seaport in the British Isles to showcase the technology to ship owners, engineers, and others of importance in the British maritime community. "Everywhere the vessel became an object of wonder and admiration," observed John Bourne, the author of the 1851 book *A Treatise on the Screw Propeller: With Various Suggestions of Improvement*.[905] In the following passage, Bourne's comments on how this trip helped overcome formidable barriers to change to steam power within the British maritime community:

> Heretofore engineers had been almost unanimous in the opinion that a screw would occasion a serious loss of power from the obliquity of its action, and the consequent dispersion of the water; and it was concluded, therefore, that it would be ineligible as a propeller. In this opinion I perfectly remember I concurred. But it was impossible to resist facts such as the performance of the *Archimedes* afforded. Ancient opinions, in many cases negligently taken up, had to be modified or abandoned; and, although few engineers would yet accept the conclusion that the screw was a better propeller than the paddle, it nevertheless became clear that their original impressions were to a certain extent erroneous, and might be erroneous altogether. Thenceforth they looked upon the screw with less distrust, and spoke with less dogmatism of its disqualifications. But at the outset it was not merely against physical difficulties, but against the almost universal sentiment of the engineering world, that the authors of the screw propeller had to work in accomplishing its practical introduction. Before these combined

[905] John Bourne, *A Treatise on the Screw Propeller: With Various Suggestions of Improvement* (London, UK: Longman, Brown,, Green and Longmans, 1852), 86.

impediments countless inventors had succumbed, and it is difficult to overrate the merit of those who, without the consolations of sympathy, and in spite of a scepticism well nigh universal, preserved their own faith unshaken, and laboured steadily onward until their labours, pains, and perils, had a final issue in successful achievement.[906]

The *Archimedes* and other early screw steamers convinced the British Admiralty of the imperative for transitioning to the screw propeller. At first, the Admiralty had been appalled by the advent of steam, believing it would "strike a fatal blow at the naval supremacy of the Empire."[907] But, the rapid technological advance made possible by screw propulsion quickly persuaded the Admiralty to reverse course, if only to keep up with the French. By 1855, during its war with Russia, Great Britain possessed a fleet of screw-powered steamers that included all classes of ships; 174 ships of the Royal Navy had been fitted with screw propulsion, including 52 ships-of-the-line, 23 frigates, 17 corvettes, 55 sloops, and various other vessels.[908] In short, the adoption of steamships within the Royal Navy was not due to a shift in those who held power on the Board of Admiralty. The admirals and civil lords that served on the Admiralty did not die off and were not replaced by younger officers with different views, as Rosen's model predicts would be a prerequisite for innovation. Rather, the Admiralty's judgment was tempered by the practicality of steam which evolved over time. Technological progress, powered by commercial interests, snowballed as the technology marched "up market." The introduction of the *Archimedes* sparked a palpable rate of technological advance. The *Great Western*, still considered one of Britain's best ships when sold to the West India Royal Mail Steam Packet

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[906] John Bourne, *A Treatise on the Screw Propeller: With Various Suggestions of Improvement* (London, UK: Longman, Brown, Green, and Longmans, 1852), 86.
[907] Niall Ferguson, *Empire: the Rise and Demise of the British World Order and the Lessons for Global Power* (New York, NY: Basic Books, 2002), 140.
[908] John Timbs, *Wonderful Inventions: From the Mariner's Compass to the Electric Telegraph Cable* (London, UK: George Routledge and Sons, 1868), 270).

Company in 1847, was scrapped a decade later as it was unable to compete profitably with the new class of steamers.[909]

Concurrent with, although independent of, Smith's efforts, another inventor John Ericsson, a Swede who lived in London, also tackled the problem of making screw propulsion practical. Bourne wrote, "Probably the exertions of either would have sufficed to introduce the screw into practical operation; but their simultaneous prosecution of the same object, was not, nevertheless, a waste of power. The progress of each was stimulated by the progress of the other, and their united force acted more powerfully upon the public, and procured for the screw a readier and wider introduction than could otherwise have been expected."[910] Two years before the *Archimedes* took to the sea, Ericsson demonstrated a small boat to senior members of the British Admiralty, but failed to impress them since the craft experienced steering difficulties. The Admiralty rejected his design. Undeterred but perturbed by the Admiralty's initial reaction to his invention, Ericson built a second, larger screw-propelled boat, the *Robert F. Stockton*, and steamed to the United States in 1839. Ericsson had impressed then Captain Stockton and found favor with the United States Navy who ordered two ships. A couple years later, Ericsson would design the Navy's first screw-propelled warship, the *USS Princeton*. The *Princeton* also had the distinction of being the first steam warship that had all of her machinery placed entirely below the water-line, out of reach of enemy cannon shot. In October 1843, the *Princeton* handily bested the *SS Great Western*, still regarded as the fastest steamer afloat, in a speed contest. Ericsson's propeller was also widely and immediately

[909] George H. Preble, *A Chronological History of the Origin and Development of Steam Navigation*, 2nd ed. (Philadelphia, PA: L. R. Hamersly & Co., 1895), 187.
[910] John Bourne, *A Treatise on the Screw Propeller: With Various Suggestions of Improvement* (London, UK: Longman, Brown,, Green and Longmans, 1852), 87.

adopted for use in commercial ships in America. By 1850, several hundred commercial vessels were propelled by the screw, and Ericsson's propeller was the design of choice for nearly all of them.

Commercial shipping markets fueled steamship technological progress from its early beginnings, allowing it to march "upmarket" from its humble early beginnings in inland waterways to displace the sailing ship in more and more markets. Sea-going sailing ships, both commercial vessels and warships, were last to make the transition to steam because the technology was not viable for those markets until after the screw propeller made deep-sea operations practical. Subsequent technological improvements served to quicken the rate of adoption because they made steamships ever more competitive. Early steam engines relied on a principle called single expansion in which cylinders were driven by boiler steam that was then exhausted. By 1854, engineers started designing engines to use double-expansion, which used the steam exhausted from one cylinder to power another cylinder. Double-expansion engines improved overall power and efficiency as well as significantly reducing coal consumption. Triple-expansion engines followed in 1873, improving engine performance even further. Additionally, ironclad steamships, protected by iron or steel armor plates, started to become the norm in the early second half of the nineteenth century. Commenting on the rate of technological progress, U.S. Naval Academy professors William Stevens and Allan Westcott in *A History of Sea Power* state, "… progress thereafter was so swift that an up-to-date ship of each succeeding decade was capable of defeating a whole squadron of ten years before."[911] Figure 18 graphs the number of steamships specifically commissioned and built for service in U.S. Navy

[911] William Stevens and Allan Westcott, *A History of Sea Power* (New York, NY: George H. Doran Company, 1920), 287.

by decade from 1810 through 1869; it shows an exponential pattern of growth after the screw propulsion made steam warships viable and attractive.

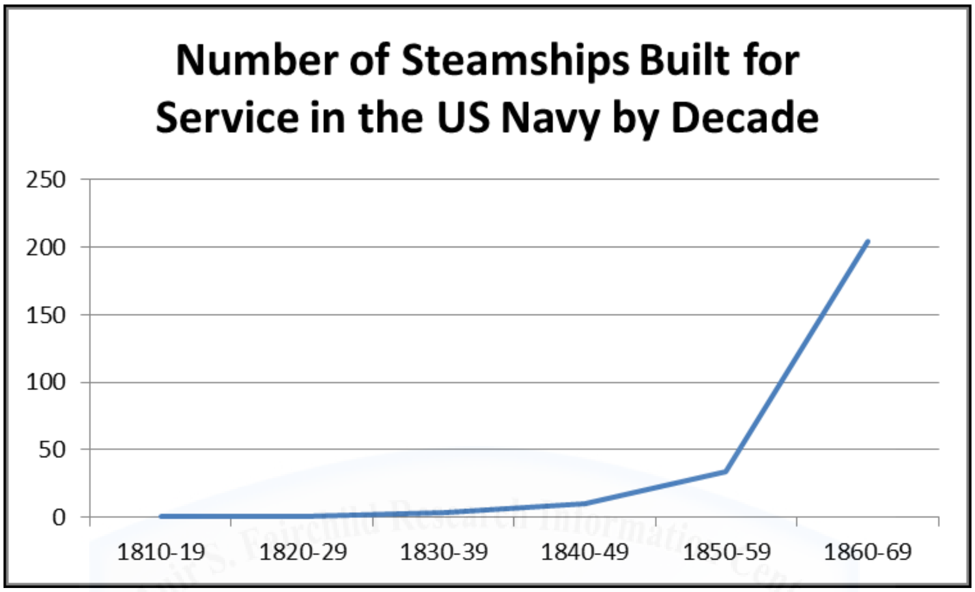

FIGURE 17 – Number of Steamships Build for Service in the US Navy by Decade

In summary, the perceived attributes of the steamboat seem to explain much of the reason why the U.S. Navy adopted the steamboat. Moreover, the transition from sail to steam appears to have followed what Clayton Christensen describes as a common path to adoption for disruptive innovations.

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